APPENDIX 1

NON-MATERIAL CHANGE APPLICATION REPORT

1. INTRODUCTION

1.1 Orsted Hornsea Project Three (UK) Limited ("**Orsted**") (company number 08584210) of registered 5 Howick Place, London, England, SW1P 1WG is the undertaker with the benefit of the Hornsea Three Offshore Wind Farm Order 2020, which was granted by the Secretary of State for Business, Energy and Industrial Strategy on 31 December 2020 (S.I. 2020 No. 1656) (the "**Order**") as corrected by the Hornsea Three Offshore Wind Farm (Correction) Order 2021 (S.I. 2021 No. 599) following an application made by Orsted.

1.2 The Order includes provision authorising the acquisition for the purpose of the construction, operation, maintenance and decommissioning of the Hornsea Project Three offshore wind farm together with associated offshore and onshore infrastructure and all associated development ("**Hornsea Three**"), on land within the former Hornsea Zone in the North Sea approximately 121 kilometres to the northeast of the north Norfolk coast and approximately 10 kilometres west of the median line between UK and Netherland waters covering an area of approximately 696 square kilometres. Hornsea Three comprises the following elements: up to 231 wind turbines; up to three offshore accommodation platforms; up to twelve offshore transformer substations; up to six subsea offshore High Voltage Alternating Current ("**HVAC**") booster stations; up to four surface offshore HVAC booster stations; subsea inter-array electrical circuits; a marine connection to shore; a foreshore connection and an onshore connection (comprising up to six export cable circuits and other associated infrastructure) to an onshore substation (which could also include an onshore HVAC booster station sited along the route); and the connection from there to National Grid's existing Norwich Main substation.

1.3 The Order requires Orsted to construct four artificial nesting structures ("**ANS**") for kittiwake along the English east coast, as a compensation measure for the potential impacts of Hornsea Three. Paragraph 3(c) of Part 1 of Schedule 14 of the Order requires four structures to be in place four full breeding seasons before Hornsea Three becomes operational. The focus of the proposed non-material change is to shorten the length of time the ANS need to be in place before operation, to allow time for necessary rights for the construction of the ANS to be obtained without impacting the programme for the operation of Hornsea Three and its provision of renewable energy to the National Grid. Discussions have been held with the Marine Management Organisation ("**MMO**"), Natural England ("**NE**") and the Royal Society for the Protection of Birds ("**RSPB**") at the Offshore Ornithological Engagement Group ("**OOEG**") Steering Group meeting held on 3rd October 2022 and no objections were raised with regards to the wording of the non-material change detailed at section 3.1 below. The changes are needed to ensure that the appropriate and agreed kittiwake compensation measures are reflected in the Order, in order that construction and implementation of the Order is in accordance with its conditions. The changes required comprise changes to paragraphs 3(c) and 4 of Part 1 of Schedule 14 of the Order, as set out at section 3 below.

1.4 The Applicant remains committed to delivering the most ecologically suitable ANS for the purposes of its habitats compensation. To achieve this aim, the Applicant requires flexibility in timing of delivery of the ANS to avoid unnecessarily delaying the provision of renewable energy from Hornsea Three.

1.5 The Applicant has made great strides towards delivering the required kittiwake compensation. The nearshore sites at Minsmere and Lowestoft are progressing well with an Agreement for Lease secured and Marine Licences imminent. It is hoped the Option will be served early in the new year to enter into Lease and subject to the discharge of the consent requirements construction will commence in February 2023.

1.6 By prioritising the ecological strength the Applicant has however encountered some unforeseen delays at other proposed ANS sites, including Hartlepool, the majority of which the Applicant has successfully resolved. The Applicant is also planning construction of the ANS at the nearshore sites in the winter months, which in the North Sea could be subject to further delay due to weather contingency as health and safety is the Applicant's top priority.

1.7 As such, the Applicant is seeking the amendments proposed in this non-material change application, to provide necessary contingency in the Hornsea Three programme to deliver the ANS.

1.8 Orsted hereby applies to the Secretary of State pursuant to section 153 and paragraph 2 of Schedule 6 of the 2008 Act to make changes to the Order that are not material (referred to hereafter as a "**Non-Material Change (NMC) Application**"). The NMC Application is subject to the Infrastructure Planning (Changes to, and Revocation of, Development Consent Orders) Regulations 2011, as amended (the "**2011 Regulations**"). This NMC Application has been prepared with reference to the Department of Communities and Local Government document 'Guidance on Changes to Development Consent Orders' (December 2015).

1.9 This document sets out the proposed non-material change to the Order sought by Orsted and the rationale for doing so and details of the consultation process undertaken. It also sets out why the changes sought in the NMC Application will not result in any materially new or materially different environmental effects, given that the changes proposed are technical and would not result in any development beyond that already consented through the Order, which has already been subject to Environmental Impact Assessment.

2. CONSULTATION PROCESS

Background

2.1 Under the 2011 Regulations, on making an NMC Application the applicant must notify and consult those persons specified in the Regulations, this being all those who were notified (in accordance with section 56 of the Planning Act 2008) when the application for the original development consent order was accepted by the Secretary of State, as well as any other person who may be directly affected by the changes proposed in the application.

2.2 Regulation 7(3) of the 2011 Regulations also provides that an applicant need not consult a person or authority specified in the Regulations if they have the written consent of the Secretary of State not to do so.

2.3 A letter of 8 November 2022 from Pinsent Masons to the Department requested written consent from the Secretary of State under regulation 7(3) of the 2011 Regulations that only the MMO, NE, the RSPB, The Crown Estate and the Joint Nature Conservation Committee ("**JNCC**") (together, the "**Proposed Consultees**") should be consulted on the non-material change application, given the nature of the changes sought and because these parties have played an active role in developing the ANS including their location, design, monitoring and adaptive management. The MMO, NE and the RSPB are active members of the OOEG, which was set up pursuant to paragraph 2 Part 1 of Schedule 14 of the Order. They also responded to the original consultation on 2nd November 2020 relating to the proposed Kittiwake Compensation Plan. In addition, Orsted has been in regular discussions with The Crown Estate, who have played an active role both from a strategic and project specific perspective in the site selection and have been kept informed of Orsted's approach to the implementation of compensation. Orsted has also been granted the necessary seabed rights by The Crown Estate for two of the proposed sites for the ANS, which will be further detailed in the supporting

documentation to this application. The JNCC are the authority for offshore nature conservation, working closely with Natural England. Orsted has already liaised with the OOEG and as noted above no objections have been raised to the proposed non-material change with its members.

2.4 On 21 December 2012, the Secretary of State confirmed that the consultee list should include the Proposed Consultees, but that the Norfolk Wildlife Trust, the Wildlife Trusts and the Norfolk Farming and Wildlife Advisory Group (together, the "**Additional Consultees**") should also be directly consulted on the NMC Application. The reasoning given was that the Additional Consultees had a possible interest in the NMC Application.

2.5 The Secretary of State agreed that all other parties need not be consulted as they are not directly affected by the NMC Application, either because the changes proposed will not affect their interests or because their interests relate to a different part of the scheme.

2.6 Accordingly, the Secretary of State gave written consent, under regulation 7(3) of the 2011 Regulations, that only the Proposed Consultees and the Additional Consultees (together, the **Consultees**") need be consulted on the NMC Application. No other parties who may be directly affected by the changes proposed in the NMC Application have been identified.

Overview

2.7 Regulations 6 and 7 of the 2011 Regulations set out the process for publicising and consulting respectively on an NMC Application. Pursuant to Regulation 7A of the 2011 Regulations, Orsted will submit a separate Consultation and Publicity Statement confirming its compliance with Regulations 6 and 7a of the 2011 Regulations.

2.8 In summary, the following has, or is being, undertaken by Orsted to comply with Regulations 6 and 7:

2.8.1 Orsted notified the Planning Inspectorate ("**PINS**") and BEIS of the intention to submit an NMC Application, on 9th May 2022 and 8 November 2022 respectively;

2.8.2 Orsted is publicising the NMC Application by publishing a notice in each of the Eastern Daily Press, the Norwich Evening News, the North Norfolk News, the Diss, Wymondham and Attleborough Mercury, the Lloyd's List and the Fishing News for two successive weeks. The notice will be published for the first time on 12th January 2023 when the NMC Application is made to the Secretary of State. A copy of the notice will be included in the Consultation and Publicity Statement;

2.8.3 the project email address HornseaProjectThree@planninginspectorate.gov.uk has been included in the notice publicising the NMC Application so that members of the public can make a formal response to PINS in relation to the NMC Application; and

2.8.4 following receipt of notice from the Secretary of State pursuant to Regulation 7(3) on 21 December 2022, the list of consultees contacted regarding the NMC Application will be the Consultees defined above.

2.9 The NMC Application will be available to view on the project website at:

https://hornseaproject3.co.uk/

and also on PINS' website at:

https://infrastructure.planninginspectorate.gov.uk/projects/eastern/hornsea-project-three-offshore-wind-farm/?ipcsection=docs

2.10 Hard copies of the NMC Application can be requested by contacting Orsted at HornseaProjectThree@orsted.com or on: +447826663963 Each hard copy is available at the cost of £20 per copy.

2.11 Consultees are invited to provide comments on the NMC Application until the closing date for consultation.

3. PROPOSED NON-MATERIAL CHANGE TO THE ORDER

3.1 The Order consists of 45 articles and 14 Schedules. This NMC Application proposes changes only to paragraphs 3(c) and 4 of Part 1 of Schedule 14. The content of these changes is set out in the table below.

Table 1 - Proposed changes to the Order

Article of the Order	Proposed change
Schedule 14, Part 1, paragraph 3(c)	Delete the existing paragraph and insert the following new text as a new paragraph: *"an implementation timetable for delivery of four artificial nest structures that ensures all necessary compensation measures are in place to allow three full kittiwake breeding seasons in respect of two artificial nest structures prior to the operation of any turbine forming part of the authorised development, and to allow two full kittiwake breeding seasons for the other two artificial nest structures prior to the operation of any turbine forming part of the authorised development, with the KIMP to specify whether the three or two breeding seasons applies to each artificial nest structure."*
Schedule 14, Part 1, paragraph 4	Delete the existing paragraph and insert the following new text as a new paragraph: *"The undertaker must implement the measures as set out in the KIMP approved by the Secretary of State and no operation of any turbine forming part of the authorised development may be commenced until three full breeding seasons have elapsed from the implementation of two of the artificial nest structures and two full breeding seasons have elapsed from the implementation of two of the artificial nest structures, as set out in the KIMP. For the purposes of this paragraph each breeding season is assumed to have commenced on 1 March in each year and ended on 30 September."*

3.2 The changes to the Order proposed are required to ensure that the appropriate and agreed kittiwake compensation measures are reflected in the Order, so that construction and implementation of the Order is in accordance with its conditions.

3.3 Orsted has produced a new Environmental and HRA report, which is appended in full at Appendix 2, in order to confirm that the proposed changes will not give rise to any materially new or materially different environmental effects from those considered in the Secretary of State's Habitats Regulation Assessment ("**HRA**") as part of the original application for the Order. The Environmental and HRA report is accompanied by a

technical report (Growth Scenarios (NIRAS 2022)) summarising the Applicants existing understanding on the likely growth rate of new colonies. In summary, the conclusions of this new report and the technical report are as follows:

3.3.1 any delay of up to a few years in either the availability of one or more of the four ANS or their colonisation by the kittiwake will have no consequence on the effectiveness of the proposed compensation measure with respect to the Flamborough and Filey Coast Special Protection Area ("**FFC SPA**") population (or wider North Sea population) or coherence of the network for kittiwake;

3.3.2 a delay of one year in installation of two of the four ANS would simply result in an equivalent delay of one year in the time for compensation to exceed mortality i.e. pay back of the mortality debt. As the planned compensation measures will be in place over the long-term (35+ years), a delay of one or a few years would have a de minimis impact on the overall success of these measures;

3.3.3 the proposed change to the number of breeding seasons does not affect the overall ecological validity of the compensation measure and does not have the potential to alter the conclusions of the HRA, including from an offshore ornithology perspective; and

3.3.4 a reduction in the timescales ANS are in place prior to the operation of Hornsea Three turbines will not conflict with the objective of compensation as set out by the SoS in the HRA i.e. the potential of structures to deliver 73 adult kittiwakes into the FFC SPA population per year.

4. SUMMARY AND CONCLUSIONS

4.1 Orsted is proposing to change the Hornsea Three Offshore Wind Farm Order 2020 (as amended) so that the appropriate and agreed kittiwake compensation measures are reflected in paragraphs 3(c) and 4 of Part 1 of Schedule 14 of the Order.

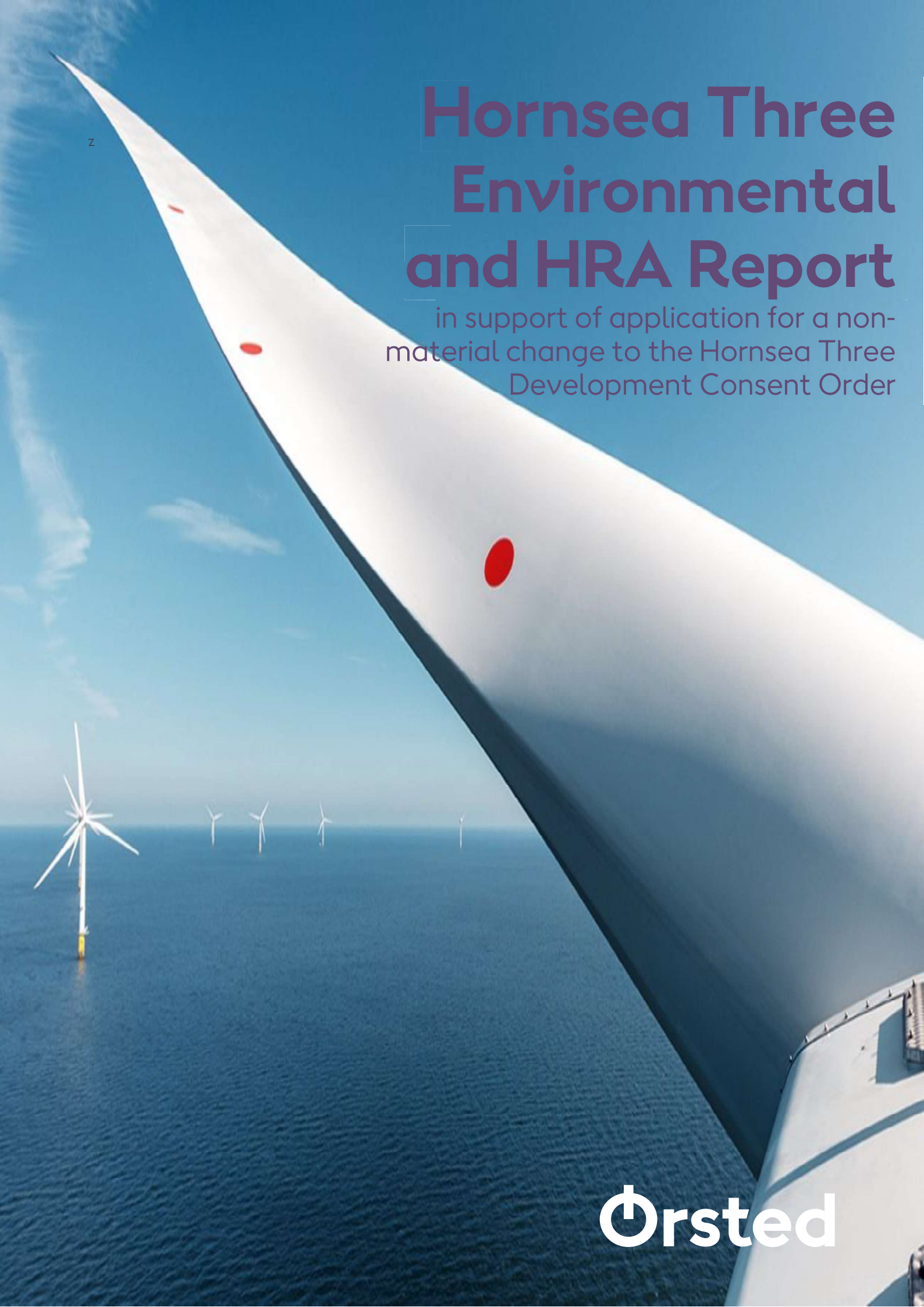
4.2 No change to the other provisions in the Order, physical development or other controls regulating the construction, operation, maintenance or decommissioning of the authorised development are proposed.

4.3 The proposed changes would not require additional compulsory acquisition of land, nor would they have new or different effects on local residents or businesses or any additional implications in respect of habitats regulation assessment. They are simply required to ensure that the appropriate and agreed kittiwake compensation measures are reflected in the Order, in order that construction and implementation is in accordance with its conditions.

4.4 Given the information presented in this document, as summarised above, it is considered that the proposed changes are non-material changes for the purposes of the Infrastructure Planning (Changes to, and Revocation of, Development Consent Orders) Regulations 2011. Accordingly, Orsted submits that the proposed changes as outlined in section 3 of this document can be granted consent by the Secretary of State as non-material changes.

APPENDIX 2

ENVIRONMENTAL AND HRA REPORT



Hornsea Three Environmental and HRA Report

in support of application for a non-material change to the Hornsea Three Development Consent Order

Ørsted

Document Control

Document Properties	
Author	Liz Morgan and Robin Ward (NIRAS)
Checked by	Felicity Le Page
Approved by	Dr Sarah Randall
Title	Hornsea Three Environmental and HRA Report in support of application for a non-material change to the Hornsea Three Development Consent Order

Version History

Date	**Version**	**Status**	**Description / Changes**
08/12/22	1	Final for consultation	n/a

Table of Contents

List of Tables

List of Figures

Acronyms

Acronym	Definition
ANS	Artificial Nesting Structure
DCO	Development Consent Order
FFC SPA	Flamborough and Filey Coast Special Protection Area
HRA	Habitats Regulation Assessment
KCP	Kittiwake Compensation Plan
KIMP	Kittiwake Implementation and Monitoring Plan
MMO	Marine Management Organisation
NE	Natural England
NMC	Non-Material Change
OOEG	Offshore Ornithology Engagement Group
RSPB	The Royal Society for the Protection of Birds
SoS	Secretary of State

1 Introduction

1.1.1.1 Orsted Hornsea Project Three (UK) Limited (hereafter 'Orsted') propose to construct four artificial nesting structures (ANS) for kittiwake along the English east coast, as a compensation measure for the potential impacts of the Hornsea Project Three Offshore Windfarm (hereafter 'Hornsea Three'). Hornsea Three's DCO states that the timetable for delivery of the artificial nest structures should ensure all compensation measures are in place to allow four full kittiwake breeding seasons prior to the operation of any turbine forming part of the authorised development.

1.1.1.2 This note supports the submission by Orsted for a non-material change (NMC) to the Hornsea Three Development Consent Order (DCO) for changes focused on shortening the length of time the ANS need to be in place before Hornsea Three becomes operational. Specifically, a change from four breeding seasons to three breeding seasons for two structures and two breeding seasons for the other two has been requested (see **Figure 1.1**). The wording of this non-material change has been agreed in principle with the OOEG (during steering group #7 on 03/10/22). This note provides an appraisal of the implications of a change to the number of breeding seasons as submitted in the NMC, on the conclusions of the Secretary of State's (SoS's) Habitats Regulation Assessment (hereafter, the HRA) for Hornsea Three. To provide context, the note summarises:

- The conclusions of the SoS's HRA for Hornsea Three in relation to kittiwake compensation and the number of breeding seasons required; and,
- The key points agreed by the Offshore Ornithology Engagement Group (OOEG)[1] when discussing deployment of the ANS with respect to designs, locations, monitoring techniques and adaptive management processes.

Proposed change to paragraph 3(c) of Part 1 of Schedule 14 of the Hornsea Three DCO:

"an implementation timetable for delivery of four artificial nest structures that ensures all necessary compensation measures are in place to allow ***three full kittiwake breeding seasons in respect of two artificial nest structures*** *prior to the operation of any turbine forming part of the authorised development, and to allow* ***two full kittiwake breeding seasons for the other two artificial nest structures*** *prior to the operation of any turbine forming part of the authorised development, with the KIMP to specify whether the three or two breeding season applies to each artificial nest structure."*

Proposed change to paragraph 4 of Part 1 of Schedule 14 of the Hornsea Three DCO:

"The undertaker must implement the measures as set out in the KIMP approved by the Secretary of State and no operation of any turbine forming part of the authorised development may be commenced ***until three full breeding seasons have elapsed from the implementation of two of the artificial nest structures and two full breeding seasons have elapsed from the implementation of two of the artificial nest structures****, as set out in the KIMP. For the purposes of this paragraph each breeding season is assumed to have commenced on 1 March in each year and ended on 30 September"*

Figure 1.1 Proposed changes to Part 1 of Schedule 14 of the Hornsea Three DCO.

[1] Under the conditions of the DCO, an Offshore Ornithology Engagement Group (OOEG). The OOEG Steering Group comprises the following core members as the named consultees: Orsted, Natural England (NE), the Marine Management Organisation (MMO) and The Royal Society for the Protection of Birds (RSPB). Orsted also invited a number of specialist consultants or delivery partners. The OOEG Technical Panel has included the OOEG Steering Group together with several additional organisations to assist in its discussions i.e Joint Nature Conservation Committee, The Department for Environment, Food and Rural Affairs, and the UK Centre for Ecology and Hydrology.

2 Hornsea Three HRA

2.1.1.1 Sections of the SoS HRA[2] for Hornsea Three have been reviewed for this report and the conclusions relating to kittiwake compensation and the number of breeding seasons required are summarised below.

2.2 Required compensation

2.2.1.1 The HRA states that:

"*With respect to provisioning of artificial nesting sites for kittiwake, The SoS stated that sufficient information has been provided to give the required level of confidence that necessary compensatory measures can be secured that will ensure the overall coherence of Natura 2000 sites for kittiwake. The SoS agreed that the objective of the compensation as the recruitment of* ***73 adult kittiwake*** *into the Flamborough and Filey Coast SPA population* ***per year*** *is appropriate*".

The HRA then describes the measures to be addressed as conditions of the DCO. The conditions set out in the HRA and DCO relevant to the proposed changes to the timelines required for the delivery of kittiwake compensation are set out in **Table 2.1** below.

2.3 Timescales

2.3.1.1 With respect to the timescales for the kittiwake compensation measure, relevant sections of text from Hornsea Three's HRA and DCO are summarised in **Table 2.1** below. Alongside these documents the KCP also sets out that Hornsea Three is committed to:

- "*Establishing and maintaining four artificial nesting structures at suitable sites on the east coast of England.*"; *and*
- Providing "*four compensatory structures at a minimum of two geographically distinct zones, with each capable of delivering the upper estimate for level of compensation required (i.e., 73 breeding adults).*"

2.3.1.2 This long-term commitment will provide compensation at a scale that has the potential to deliver four times the estimated impact from Hornsea Three, in addition to appropriate monitoring and adaptive management measures to ensure success. Furthermore, the measure will be maintained for at least the operational lifetime of the wind farm (the period within which collision mortality would occur). No change is proposed to these commitments within the KCP by the NMC. It is important to note that within the KCP there is no reference to timescales for implementation of the ANS prior to the windfarm becoming operational.

Table 2.1 Extracts from BEIS Hornsea Project Three Habitats Regulation Assessment And Marine Conservation Zone Assessment December 2020 (emphasis added)[3]

HRA Text	DCO Text
[Section 14.1] A Kittiwake Implementation and Monitoring Plan (KIMP) should be developed by the Applicant in consultation with the OOEG. The KIMP should deliver the strategy set out in the KCP [Kittiwake Compensation Plan] and be submitted to the Secretary of State for approval (in consultation with the Marine Management Organisation, the relevant planning authority and Natural England) within sufficient time to provide the agreed compensation measures **four full breeding seasons** before the operation of the first wind farm generator.	[Schedule 14, Part 1, Para 4.] The undertaker must implement the measures as set out in the KIMP approved by the Secretary of State and no operation of any turbine forming part of the authorised development may be commenced until **four full breeding seasons** following the implementation of the measures set out in the KIMP have elapsed. For the purposes of this paragraph each breeding season is assumed to have commenced on 1 March in each year and ended on 30 September.

[2] SoS HRA available online at - https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-003267-EN010080%20Hornsea%20Three%20-%20Habitats%20Regulations%20Assessment.pdf
[3] SoS HRA available online at - https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-003267-EN010080%20Hornsea%20Three%20-%20Habitats%20Regulations%20Assessment.pdf

HRA Text	DCO Text
[Section 14.1] The KIMP should include: iii. An implementation timetable for the delivery of the artificial nest structures that ensures all compensation measures are in place in time to allow **four full kittiwake breeding seasons prior** to the operation of any turbine.	[Schedule 14, Part 1, Para 3 (c)] an implementation timetable for delivery of the artificial nest structures that ensures all compensation measures are in place to allow **four full kittiwake breeding seasons prior** to the operation of any turbine forming part of the authorised development.
[Section 14.1] Furthermore, [the ANS] should be maintained beyond the operational lifetime of the wind farm if they are colonised. The routine and adaptive management measures, and monitoring should continue whilst the artificial nesting structures are in place.	[Schedule 14, Part 1, Para 7.] The artificial nest structures shall be maintained beyond the operational lifetime of the authorised development if they are colonised, and routine and adaptive management measures and monitoring must continue whilst the artificial nesting structures are in place.

3 Implications on HRA conclusions

3.1 Introduction

3.1.1.1 The requested reduction in the number of breeding seasons was not a material consideration upon which the SoS based his HRA conclusions for the reasons set out in this report. It is also noted that the number of breeding seasons was not expressly stated within the KCP. The key point considered by the SoS in his decision was the number of birds for which Hornsea Three has to compensate (i.e. 73 birds), with the conclusion that 400+ nests would be a sufficient number of nests to fulfil the necessary compensation requirements. The number of breeding seasons the structures should be in place prior to Hornsea Three becoming operational was stipulated as a simple measure that reflected the average age kittiwake could recruit into the wider breeding population and would indicate the likelihood of further colonisation of the ANS. This would also indicate at an early stage (prior to turbine operations) whether additional management measures might be needed to increase productivity. A mathematical appraisal was developed further to the SoS decision to give greater confidence as to the likely growth rate of new colonies on ANS. The results of these growth rate scenarios are discussed in the **section 3.2** below.

3.2 Growth Rate Scenarios

3.2.1.1 This section begins by summarising Orsted's existing understanding on the likely growth rate of new colonies, as described in the supporting technical report on Growth Scenarios (NIRAS 2022). An appraisal of this is then provided to demonstrate that the implications of a change to the number of breeding seasons is consistent with the conclusions of the HRA.

3.2.2 Potential impact of a delay on SPA populations and network coherence

3.2.2.1 Projecting the growth rate of a new artificial nesting site is challenging, as data on the colonisation of artificial structures is limited (Ørsted 2020). At natural sites, new colonies are usually created by young birds and will typically grow rapidly, but thereafter increase at a progressively lower rate (Coulson 2011, Kidlaw *et al.* 2005). Their initial growth for the first ten years or so has been found to be typically of an annual (compound) rate of increase of 50-80% amongst UK colonies (Coulson 2011). Thereafter, growth rate of the larger and older colonies having declined to around 10%–20% per annum or less (Coulson 2011, Kidlaw *et al.* 2005).

3.2.2.2 There is for all breeding populations, a range of parameter value combinations below which a colony is not self-sustaining and before which, excess productivity falls below a specified level e.g. dispersal of 73 breeding adults in to the wider population as referred to in the HRA. What is of ecological pertinence to Hornsea Three is that cumulatively across the four ANS, the agreed annual excess productivity is attained and maintained, with the accrued debit fully compensated, at a point within the windfarm's operational lifespan. The Growth Scenarios Technical Report (NIRAS 2022) has presented a range of scenarios that include where the colony growth rate, productivity and number of nests at initial colonisation, lie within

the range of recent natural variability of these parameters at existing colonies along the east coast of England.

3.2.2.3 It is where these combinations of parameter value lie inside the range of recent natural variability along the east coast of England, that a single ANS is predicted to succeed to accumulated adult production that exceeds 25% or more of the accumulated mortality from collision predicted over 35 years. The time it would take the ANS to exceed 25% of the accrued mortality debt from predicted collisions at Hornsea Three (i.e. 73 kittiwakes per year x *n* years of the windfarm being operational) has been estimated at 6-21 years from initial colonisation (NIRAS 2022).

3.3 Appraisal of implications of a change to the number of breeding seasons on the conclusions of the SoS's HRA

3.3.1.1 Whilst all four ANS will have the capacity to each support 467 nesting pairs of kittiwake, providing the required compensation when using a precautionary, yet realistic, set of assumptions (Ørsted 2020), the metric of success is linked directly to the overall productivity of the four ANS to cumulatively deliver 73 kittiwakes per year to the existing wider breeding population. Orsted expects all four structures to be populated given that there has been a thorough site selection and careful design process. There is a high likelihood of achieving more than the target of 404 nesting pairs per year cumulatively across the four ANS as they provide a 4:1 compensation ratio in nest site provisioning.

3.3.1.2 The NMC to the Hornsea Three DCO is for changes focused on shortening the length of time the ANS need to be in place before Hornsea Three becomes operational; specifically, a change from four full breeding seasons to three full breeding seasons for two structures and two breeding seasons for the other two structures. Colonisation could occur within the first breeding season after construction, or may take a few years. However, scenarios for ANS colony growth where the controlling parameter values lie within the range of recent natural variability (NIRAS 2022), suggest any delay of up to a few years in either the availability of one or more of the four ANS or their colonisation by the Kittiwake will have **no consequence on the effectiveness of the proposed compensation measure** with respect to the Flamborough and Filey Coast Special Protection Area (FFC SPA) population (or wider North Sea population) or coherence of the network for Kittiwake. Such a delay in the annual excess productivity being attained and maintained, with the accrued debit fully compensated, is proportionately small temporally and numerically in the wider context, that it will not represent any meaningful and detectable impact in the coherence of the network for Kittiwake.

3.3.1.3 The number of breeding seasons recommended by SNCB's during consultation on the KCP was an indicative guideline based on the average age kittiwakes are likely to recruit into the breeding population. Colony formation on ANS will take time to reach the population level required to deliver compensation, this may mean that compensation targets are not met within the first few years post ANS construction. Subsequent to the SoS's decision, this likely delay in colonisation was acknowledged by OOEG members. Mechanisms to address any accumulation debt resulting from the wind farm being operational prior to the required colonisation level being achieved were discussed and debt/surplus calculations were subsequently agreed upon (OOEG Technical Panel #7 on 10/11/2021). Modelled scenarios indicate the ANS are likely to pay off any debt well within the lifetime of the windfarm and any further growth would result in a surplus in future years. So, a delay of one year in installation of two of the four ANSs would simply result in an equivalent delay of one year in the time for compensation to exceed mortality i.e. pay back of the mortality debt. As the planned compensation measures will be in place over the long-term (35+ years) so a delay of one or two years would have a de minimis impact on the overall success of these measures.

3.3.1.4 Pertinent to a discussion on shortening the length of time the ANS need to be in place before Hornsea Three becomes operational is the behaviour of prospecting kittiwake. Whilst colonists of an ANS will not nest in a year when a structure is completed during the first half of the breeding season, the structure will still be available to birds prospecting in that year prior to breeding. Prospecting of Kittiwake peaks in the middle of chick rearing, with most individuals prospecting active colonies into which they are recruited, the year before breeding (Reed *et al.* 1999).

3.3.1.5 From these results it is clear is that the change in the number of breeding seasons does not change the conclusion of the HRA. The proposed change to the number of breeding seasons does not affect the

overall ecological validity of the compensation measure and does not have the potential to alter the conclusions of the HRA. A reduction in the timescales ANS are in place prior to the operation of Hornsea Three turbines will not conflict with the objective of compensation as set out by the SoS in the HRA i.e. the potential of structures to deliver 73 adult kittiwakes into the FFC SPA population per year.

4 Summary of Points of agreement from the OOEG

4.1.1.1 A total of fifteen OOEG meetings have been held, as of November 2022. The key topics discussed during these sessions were locations for the ANS, design of the ANS and plans for monitoring and adaptive management.

4.1.1.2 Through this process, agreement was reached on the areas to progress within the East Anglia and North East search zones. This followed a thorough site selection process which considered kittiwake ecology, technical feasibility, planning constraints and land availability. Specifically, the OOEG agreed (during meetings on 07/07/2021 and 29/09/2021), that the Old Hartlepool Yacht Club has strong potential for colonisation by kittiwake, given its very close proximity (30 m) to an existing kittiwake colony which occupies the walkway to the lifeboat pontoon. Further, the OOEG agreed that the Lowestoft and Minsmere locations were strong ecologically, particularly favouring a marine structure, during meetings held on 27/05/2021, 18/08/2021, 10/11/2021, 15/12/2021 and 13/04/2022. Further locations are currently being discussed with the OOEG and alignment has been reached regarding their merits. The ecological site selection criteria was also agreed with the OOEG, and proximity of these sites to existing kittiwake colonies provides the highest likelihood of success.

4.1.1.3 Detailed ecological design principles were discussed and agreed with the OOEG, for example specific dimensions of nesting compartments, overhangs and measures for predator management. The onshore ANS designs evolved following feedback from each OOEG meeting and agreement on the final designs was achieved (during meeting held on 10/11/2021). Similarly, the nearshore designs incorporated the same principles and the OOEG were aligned on the final designs.

4.1.1.4 The approach to monitoring and adaptive management were discussed with the OOEG alongside the drafting of the Kittiwake Implementation and Monitoring Plan (KIMP). Agreement was reached on the type and methods of monitoring to be conducted annually at each ANS and a hierarchy approach to adaptive management was agreed on 10/11/2021, alongside flow diagrams which represent the process. The OOEG agreed that the statistical approach to mortality debt and growth rates presented on 13/06/2022 was suitable. This statistical model was developed following the SoS's decision to grant development consent to Hornsea Three and did not inform the conclusions of the HRA. It reflects more up-to-date discussions held with Orsted and Natural England and is a more appropriate model to allow an assessment of the measure of success over time and to determine whether adaptive management is required.

4.2 Number of structures

4.2.1.1 The number of ANS required was agreed upon following discussions with SNCB's (prior to formation of the OOEG) and is specified in the KCP which is certified under the DCO. Each structure has been designed with the capacity to produce enough breeding adult kittiwake to compensate for 73 collisions. Estimates of required nesting space are based on detailed population calculations (see Ørsted 2020) using the most precautionary end of the potential impact range (i.e., an estimate of 65-73 adult birds). ANS capacity is therefore based on the upper most precautionary limit which translates to 404-467 pairs of breeding kittiwake. The proposed scale of the compensatory measure will be such that it can provide sufficient nesting space to support at least 404-467 breeding pairs at each structure, each ANS will therefore have the potential to fulfil the necessary compensation requirements alone. Recognising that the compensatory measure proposed has the potential to offset four times the SoS' upper estimate of kittiwake mortality.

4.2.1.2 Despite this, the establishment of multiple new colonies was recommended by Orsted (see Ørsted 2020) to give resilience to the compensatory measure. Having multiple structures is also likely to minimise on

the lead in time to achieve the requisite number of birds at each ANS, and act to buffer against stochastic events.

4.2.1.3 Natural England shared this view when in response to the SoS's Minded to Approve Letter (Appendix 1: Compensatory Measures Sept 2020) they advised that **four structures** with approximate capacity of 400+ nests each would be suitable to compensate for an impact of 104 kittiwake/year. While Orsted was not in agreement with Natural England that 104 breeding adults is the appropriate metric of this compensatory measure, they made a commitment to provide four ANS at this scale to resolve any practical consequence of this disagreement and to maximise colonisation success and ensure resilience of the measure (see Response to the Secretary of State's Minded to Approve Letter Appendix 2: Kittiwake Compensation Plan).

4.2.1.4 The KCP therefore states that four structures will be provided [paragraph 1.9]:

"*In providing four compensatory structures at a minimum of two geographically distinct zones, with each capable of delivering the upper estimate for level of compensation required (i.e., 73 breeding adults), the Applicant is ensuring that significant contingency is built into the measure to provide the necessary confidence that it will substantively offset the impact in all actual impact scenarios from the Hornsea Three wind farm*".

This commitment will also be included within the KIMP.

5 Implications on the conclusions of the offshore ornithology section of the EIA

5.1.1.1 Hornsea Three's offshore ornithology EIA concluded with respect to potential impacts on kittiwake, that during construction and operational phases of the windfarm:

- Indirect effects, such as changes in habitat or abundance and distribution of prey will be negligible;
- The impact of pollution including accidental spills and contaminant releases which may affect species' survival rates or foraging activity will be negligible (providing development of, and adherence to, a CoCP);
- There may be a minor adverse effect on mortality from collision with rotating turbine blades;
- The impact from barrier effects caused by the physical presence of turbines and ancillary structures may prevent clear transit of birds between foraging and breeding sites, or on migration, will be negligible or may have a minor adverse effect;
- The impact of attraction to lit structures by migrating birds in particular may cause disorientation, reduction in fitness and possible mortality will be negligible or may have a minor adverse effect; and
- The impact of pollution including accidental spills and contaminant releases associated with maintenance or supply/service vessels which may affect species' survival rates or foraging activity will be negligible.

5.1.1.2 Orsted's position is that a change to the number of breeding seasons ANS are in place prior to windfarm operations does not alter any of these conclusions. Therefore, the NMC proposal is consistent with the conclusions of the offshore ornithology section of the EIA.

6 Conclusions

6.1.1.1 The kittiwake compensation measures will be achieved and secured regardless of any delay to the timing of the delivery. The proposed changes to the length of time the ANS need to be in place before Hornsea Three becomes operational, will not give rise to any materially new or materially different environmental effects from those considered in the HRA.

6.1.1.2 Hornsea Three will contribute significantly to the UK Government's ambition (as set out in British Energy Security Strategy) of 50 GW offshore wind capacity by 2030 and net zero carbon emissions by 2050, which are crucial in the fight against climate change. Climate change is listed in the International Black-

legged Kittiwake Conservation Strategy and Action Plan[4] as a key factor which is affecting adult mortality and breeding success. The main pathway for changing climate to impact kittiwake is likely to be through indirect trophic interactions and associated changes in the abundance and distribution of their main prey species, but also through changing patterns of extreme weather events. Accelerating the switch to renewable energies could also benefit kittiwake populations by reducing the impact of climate induced adverse effects on kittiwake.

[4]International Black-legged Kittiwake Conservation Strategy and Action Plan: https://oaarchive.arctic-council.org/bitstream/handle/11374/2639/MMIS12_2021_REYKJAVIK_CAFF_cbird_kittiwake_conservationstragetyactionplan.pdf?sequence=1&isAllowed=y

7 References

Coulson, J.C. (2011). *The Kittiwake*. T. & A.D. Poyser, London.

Kildaw, S.D., Irons, D.B., Nysewander, D.R. & Buck, C.L. (2005). Formation and growth of new seabird colonies: the significance of habitat quality. *Marine Ornithology* 33: 49-58.

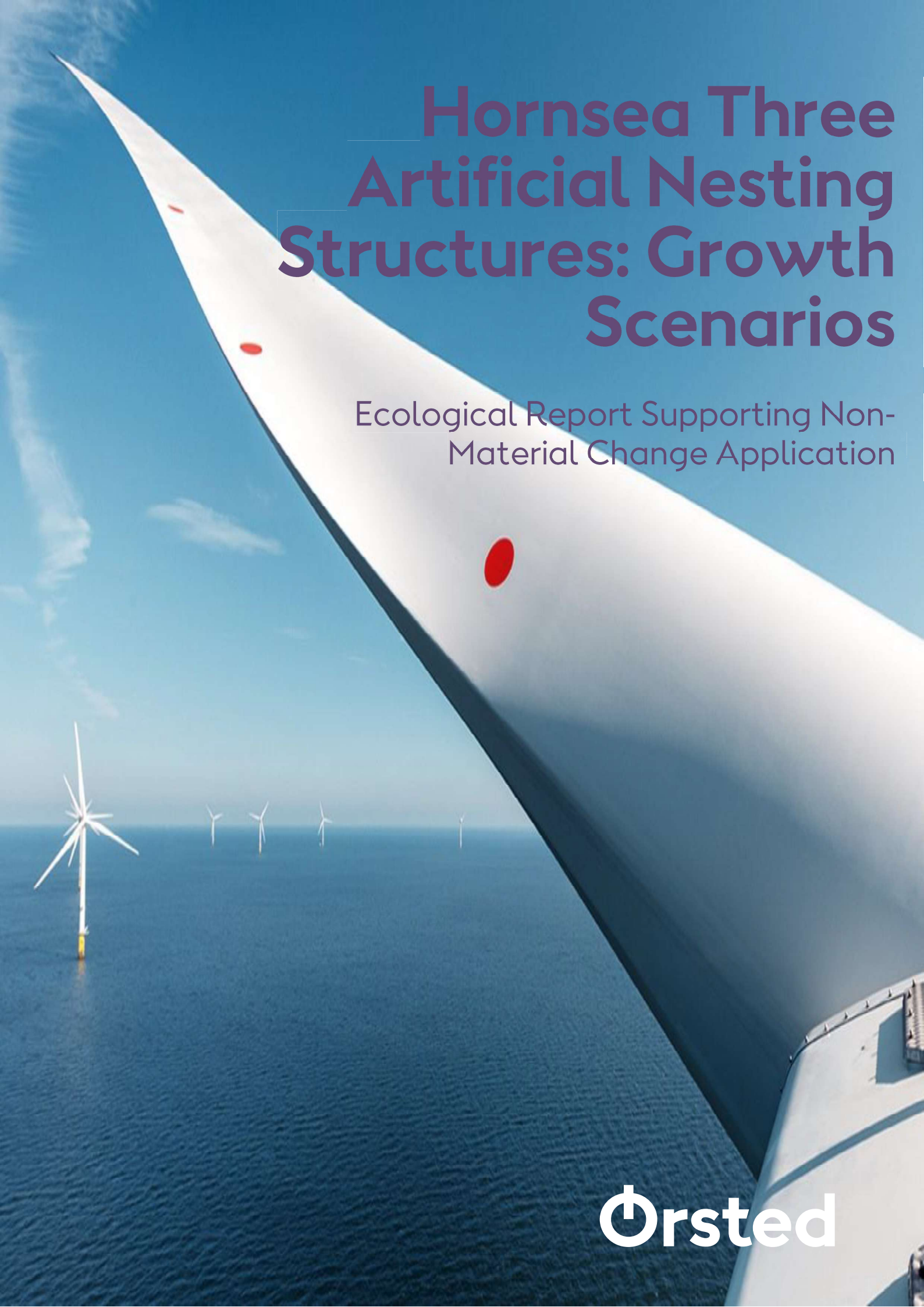
NIRAS (2022). *Hornsea Three Artificial Nesting Structures: Growth Scenarios. Ecological Report Supporting Non-Material Change Application*. Report commissioned by Orsted. NIRAS Group (UK) Ltd., Cambridge, UK.

Ørsted (2020). *Response to the Secretary of State's Minded to Approve Letter Annex 2 to Appendix 2 (Kittiwake Compensation Plan): Kittiwake Artificial Nest Provisioning: Ecological Evidence.* Ørsted Hornsea Project Three (UK) Ltd., London.

Reed, J.M., Boulinier, T., Danchin, E., Oring, L.W. (1999). Informed Dispersal. In: Nolan, V., Ketterson, E.D., Thompson, C.F. (eds) Current Ornithology. Current Ornithology, vol 15. Springer, Boston, MA. https://doi.org/10.1007/978-1-4757-4901-4_5

APPENDIX 3

GROWTH SCENARIOS REPORT (NIRAS 2022)



Hornsea Three Artificial Nesting Structures: Growth Scenarios

Ecological Report Supporting Non-Material Change Application

Ørsted

Document Control

Document Properties	
Author	NIRAS Group (UK) Ltd.
Checked by	Eleni Antoniou (Orsted)
Approved by	Karma Leyland (Orsted)
Title	Hornsea Three Artificial Nesting Structures: Growth Scenarios Ecological Report Supporting Non-Material Change Application

Version History

Date	Version	Status	Description / Changes
26/07/2022	1	Final	Final as submitted to the Offshore Ornithology Engagement Group
12/12/2022	2	Final	Final as submitted to BEIS as part of application for a non-material change to the Hornsea Three DCO

Table of Contents

List of Tables

List of Figures

Acronyms

Acronym	Definition
AON	Apparently Occupied Nests
ANS	Artificial Nesting Structures
BEIS	Department for Business, Energy and Industrial Strategy
CPO	Compulsory Purchase Order
NMC	Non-Material Change

1 Introduction

1.1.1.1 Orsted Hornsea Project Three (UK) Limited (hereafter 'Orsted') propose to construct four artificial nesting structures (ANS) for kittiwake along the English east coast, as a compensation measure for the potential impacts of the Hornsea Project Three Offshore Windfarm (hereafter 'Hornsea Three').

1.1.1.2 This note considers a range of scenarios for colony growth, productivity and size of the starting colony at an ANS. In doing so, it identifies a range of predictions of the likely timescale within which the proposed compensation can be expected to achieve its aims.

2 Potential Amendment to the Hornsea Three Development Consent Order (DCO)

2.1.1.1 Orsted has made great strides towards delivering Hornsea Three's required kittiwake compensation and remains confident in its overarching strategy to deliver compensation that is robust, ecologically strong and deliverable ahead of Hornsea Three becoming operational.

2.1.1.2 Orsted have had early discussions with the department for Business, Energy and Industrial Strategy (BEIS) regarding the possibility of submitting a non-material change (NMC) to the Hornsea Three DCO. This will ensure Orsted can expedite delivery of UK Offshore Wind Energy targets of 50 GW by 2030 and progress strong sites for ANS which will be fundamental in demonstrating deliverability of compensation for the pipeline of future projects.

2.1.1.3 Orsted has received legal advice and is confident that the amendment to the DCO would be considered non-material as there would be no change in the impact either in EIA or HRA terms, just in the practical implementation of the measures. Further, Orsted are not looking to acquire additional rights through the DCO, and any land acquisition would be done via the Electricity Act 1989.

3 Potential for colonisation

3.1.1.1 The proposed ANS are to be intentionally positioned in close proximity to existing colonies where productivity is high. For example, an estimated 1.27 fledged chicks per nest as recorded at Lowestoft (Suffolk) and Hartlepool (County Durham) in 2021 (NIRAS 2021) and in 2022, respectively 0.99 and 1.15 fledged chicks per nest (NIRAS 2022). Kittiwake are colonial nesting species so are strongly attracted to areas where other kittiwake are already nesting. In addition to this, areas where populations are increasing and breeding success is high (which is the case at Hartlepool, Seaham, Lowestoft and Sizewell (Suffolk)), are more attractive to birds wanting to recruit into the breeding population and are indicative of favourable environmental conditions (e.g. prey resource availability in the region). Existing colonies which are known to have growing populations (which indicate good productivity) show that prey availability is not likely to be a constraint locally.

3.1.1.2 Birds require social stimulation of other breeding pairs to initiate breeding activities (Coulson 2011). Therefore, a combination of calls, decoys and nests will be incorporated into initial structure design of the ANS to further initiate colonisation by breeding kittiwake (Orsted 2020).

3.1.1.3 Orsted expect all proposed ANS to be populated given that there has been a thorough site and careful selection and design process. There is a high likelihood of achieving more than the target of 404 nesting pairs per year cumulatively across the ANS as they provide a 4:1 compensation ratio in nest site provisioning.

4 Colony growth

4.1 Growth rate

4.1.1.1 Projecting the growth rate of a new artificial site is challenging as data on the colonisation of artificial structures is limited (Orsted 2020). At natural sites, new colonies are usually created by young birds and will typically grow rapidly, but thereafter increase at a progressively lower rate (Coulson 2011, Kidlaw *et al.* 2005). Their initial growth for the first ten years or so has been found to be typical of an annual (compound) rate of an increase of 50-80% amongst UK colonies (Coulson 2011). Thereafter, growth rate

of the larger and older colonies having declined to around 10%–20% per annum or less (Coulson 2011, Kidlaw *et al.* 2005).

4.2 Realistic scenario of colony growth

4.2.1 Coquet Island's kittiwake breeding population trajectory

4.2.1.1 Coquet Island (Northumberland) has been monitored since colonisation and initial breeding began in 1991, so is likely to present a scenario for establishment of a new colony at a new site where birds had not bred prior. Furthermore, kittiwake had not previously bred nearby to Coquet, thus providing what is likely to be a precautionary scenario, which is perhaps exemplified by the colony being initiated by only one breeding pair in 1991 [1]. In addition, the colony has been limited by available nesting space, running out of natural cliff ledges in recent years which has led to RSPB providing artificial nesting ledges from 2019 (Morrison 2021[2]). The result is a colony that has continued to expand to 466 apparently occupied nests (AON) in 2021, which happens to be one nest less than the upper end of the range required for the Hornsea Three ANS compensation using the worst case scenario as detailed in Orsted (2020).

4.2.1.2 The growth rate of the kittiwake colony at Coquet Island conforms with that described for starting colonies in general. The annual (compound) rate of increase is:

- 63% in the first ten years, declining to,
- 10% for the second ten year period (2001-2010), and
- 9% for the last ten real data years (2012-2021), and
- In using a ceiling of 467 AON, a modelled 0.2%[3] for the period years 26 to 35 using a logistic growth rate for those four years after the last real count data in 2021.

4.2.1.3 The growth rate of the kittiwake colony at Coquet Island is used in this note as the basis to predict how quickly the proposed compensation for Hornsea Three would achieve its aims following a delay in the installation of two of the four ANS.

4.2.2 Logistic growth rate model

4.2.2.1 Natural England has previously stated that whilst recognising the limited data available to predict the likely growth of a generic colony, a 10% per annum growth rate would be more appropriate for the lifetime of the wind farm. This is based on Natural England advice when commenting on a comparable kittiwake compensation project for Norfolk Boreas offshore wind farm, where they also acknowledged that a 20% growth rate may well be achieved or exceeded in the early years of the colony (Natural England 2021). To accommodate this viewpoint in the absence of any in-situ examples from which to inform, a logistic growth rate model (Vandermeer 2010) is presented as an alternative scenario to using the population trajectory observed at Coquet Island and elsewhere. In logistic growth, a breeding population's per capita growth rate gets smaller and smaller as population size approaches a maximum imposed by limited resources in the environment, in the current scenario that is nesting space. For the model used in this note, the logistic growth curve for the breeding population commences with a 20% growth in accordance with Natural England's view on what may be achieved in the early years of the colony (Natural England 2021), together with a 50% and 80% initial growth rate in accordance with the findings of Coulson (2011).

[1] In contrast to Coquet Island with no nearby colonies, all ANS will have existing breeding kittiwakes at or within 3 km.
[2] https://community.rspb.org.uk/ourwork/b/natureshomemagazine/posts/handy-hammocks---getting-creative-for-kittiwakes , https://www.theambler.co.uk/2021/10/14/bumper-seabird-season-on-coquet-island/
[3] 0.2% is the growth rate required to increase from 466 to 467 nests i.e. 0.2% = ((466/467) – 1) x 100

4.3 Size of the starting colonies

4.3.1.1 Kidlaw *et al.* (2005) described the growth of colonies in Alaska and record that they are typically founded by variable numbers of pioneers (23 pairs on average). Within the UK, Coulson (2011) noted that new colonies are usually formed by between three and 20 nesting pairs.

4.3.1.2 This note presents two scenarios including both the logistic growth rate model and models following Coquet Island's kittiwake breeding population trajectory but based on differing initial colony sizes:

- Scenario one: uses a starting position of one nest in year 1, the same scenario as founded the Coquet Island colony; and
- Scenario Two: shows an alternative scenario, based on a starting colony size of 25 AON's in year one, following Natural England's recommendation (during the Offshore Ornithology Engagement Steering Group meeting held on 13th June 2022).

5 Productivity

5.1.1.1 To achieve a sustainable kittiwake population, annual breeding success should be maintained at at least 0.8 chicks per nest (Coulson 2017) when adult survival rates are that of recent years (1985-2015), with no evidence of any change since. The latter threshold approximates to the regional-specific productivity that had earlier been estimated by Horswill and Robinson (2015) for the east coast of Britain (i.e., 0.819). At a site level, between 1991-2019, 1.12 fledglings per pair were produced at the kittiwake colony at Coquet Island, and 1.07 fledglings per pair for the last five of those years (2015-2019). Whereas for the last five year period for which data is available, the number of fledglings per pair has been 0.6 at Flamborough Head and Bempton Cliffs (2015-2019; within Flamborough and Filey Coast SPA), and 1.025 at Lowestoft (2013-2017). At the latter site, Lowestoft, productivity has been estimated as high as 1.27 fledged chicks per nest as in 2021, which in that year matched productivity at Hartlepool (Orsted 2021), another planned location for the Hornsea Three ANS.

5.1.1.2 Four productivity values are used as a basis to predict how quickly the proposed compensation for Hornsea Three would achieve its aims:

- Firstly, the actual productivity observed for each year of growth of the kittiwake colony at Coquet Island is used as the primary source, given its unique insight into the full trajectory of kittiwake colony growth from colonisation.
- To provide context, the growth rate of the colony observed at the Coquet Island is also modelled using three productivity values defined as:
    - "Low" – 0.8 fledglings per nest, the threshold for a sustainable colony detailed by Coulson (2017);
    - "Medium" – 1.025 fledglings per nest, the average productivity of the last five year period (2013-2017) for which data is available at Lowestoft, being representative of the region where ANS are proposed; and
    - "High" – 1.27 fledglings per nest, the peak productivity of the last two years (2021, 2022) at Lowestoft.
- For the logistic growth curve model, productivity was set at the above defined low, medium and high productivity values.

6 Survival rates and age of first breeding

6.1.1.1 Parameterisation of both models (that which replicated kittiwake colonisation of Coquet Island (**4.2.1**), and the logistic growth rate model (**4.2.2**)) required several additional factors to be considered:

- The survival rate of kittiwake varies by age, with juvenile birds typically experiencing slightly higher levels of mortality than older birds. In alignment with the review of seabird demographic rates by Horswill and Robinson (2015), the following survival rates used were:
    - Juvenile survival (0-1 years) = 0.790
    - Adult survival (≥2 years) = 0.854

- Age at which birds start to breed (age of recruitment) = four years of age (Horswill and Robinson 2015)

7 Computational steps of the models

7.1.1.1 **Table 7.1** presents the stepwise progression of the computational process in each of the two models used to determine the likelihood of when the cumulative adult production from chicks fledged at the ANS, begins to exceed the accrued mortality debt from predicted collisions at Hornsea Three.

Table 7.1 Stepwise calculation of the cumulative total of the production of adults from ANS when using a model that either (a) replicates kittiwake colonisation of Coquet Island and (b) that uses the logistic growth rate model

Successive steps of the analysis	Formulas used (using the parameters identified in first and third columns)	Value
(a) Breeding season of ANS		t
(b) Initial colony size (AON): 1 nest 25 nests		 1 25
(c) Initial colony growth rate: Low Medium High Colony growth rate as annually recorded at Coquet Island (1991 - 2021)		 20%[4] 50%[5] 80%[6] Colony growth rate as annually recorded at Coquet Island
(e) Carrying capacity of ANS (i.e. no. of nesting spaces)		467
(f) Colony size (AON) in t^{th} breeding season of ANS: Logistic growth rate model Growth in colony size as annually recorded at Coquet Island (1991 - 2021)	$f_{t-1} \times c \times ((e - f_{t-1})/e) + f_{t-1}$ Coquet Island colony size (1991 - 2021). where 1991 is $t = 1$[7]	
(g) Productivity (fledglings/nest): Low Medium High Productivity as annually recorded at Coquet Island (1991 - 2021)		 0.8[8] 1.025[9] 1.27[10] 0.4 – 1.69[11]
(i) No. of chicks fledged in year t from ANS	f x g	
(h) Survival rate of juvenile birds		0.79[12]
(i) No. of year t cohort of fledged birds from ANS surviving first year	h x i	
(j) Survival rate of sub-adults/adults		0.854[13]
(k) No. of year t cohort of fledged birds from ANS surviving second year	j x i	
(l) No. of year t cohort of fledged birds from ANS surviving third year	j x k	
(m) No. of year t cohort of fledged birds from ANS surviving fourth year	j x l	
(n) Cumulative total of the production of adults	$\sum_{1}^{t} m$	

[4] Natural England (2021)
[5] Coulson (2011)
[6] Coulson (2011)
[7] Seabird Monitoring Programme https://app.bto.org/seabirds/public/index.jsp
[8] Coulson (2017)
[9] 5 year mean (2013-2017), Lowestoft
[10] Peak productivity in 2021 and 2022, Lowestoft (NIRAS 2021, 2022)
[11] Coquet Island from 1993 to 2019 (Seabird Monitoring Programme https://app.bto.org/seabirds/public/index.jsp)
[12] Horswill and Robinson (2015)
[13] Horswill and Robinson (2015)

8 Delivery

8.1 Scenario One - initial colony size of one Apparently Occupied Nest (AON)

8.1.1.1 Figure 8.1 to 8.5 show the cumulative production of kittiwake and accumulated kittiwake mortality from predicted collisions at Hornsea Three. Each model is based on an initial colony size of one AON on the ANS at the point in time when the windfarm becomes operational. Parameters include:

- The growth rate replicating that of Coquet Island with productivity replicating that at either:
  - Coquet Island (between 0.4 – 1.7 fledglings per pair, mean of 1.1; 1991-2019); or
  - Lowestoft in 2021 (1.27 fledglings per pair) defined as "High"; or
  - Lowestoft (1.025 fledglings per pair; 2015-2017) defined as "Medium"; or
  - Colonies attaining the threshold of being sustainable (0.8 fledglings per pair; Coulson 2017) defined as "Low"; or
- A logistic growth rate of 50% with productivity set at 0.8 fledglings per pair.

8.1.1.2 Each figure provided is for one ANS, there being four ANS proposed for the Hornsea Three kittiwake compensation measure, and therefore progress should be viewed in delivering the compensation cumulatively across the structures which equates to 73 additional birds per annum over the lifetime of the Hornsea Three (35 years). If colonisation, growth rate and productivity were equal across all four ANS, then the compensation measure would be delivered cumulatively across the structures when the cumulative production of adults at each ANS attains 25% cumulative mortality from predicted collisions at Hornsea Three (i.e. 639 additional breeding birds contributing to the existing wider breeding population[14]). This would be achieved between the 21st and 24th breeding season of an ANS depending on the four productivity scenarios above. Moreover, the cumulative adult production from chicks fledged at the ANS, begins to exceed 25% of the accrued mortality debt[15] from predicted collisions at Hornsea Three from between the 11th and 20th breeding season of an ANS depending on the four productivity scenarios above.

8.1.1.3 The ANS will cumulatively provide nesting opportunities for approximately 2,000 breeding pairs of kittiwake. However, it is unlikely that the maximum capacity will ever be achieved. ANS generally do not reach full capacity, for example the Gateshead kittiwake Tower, South Shields, has an occupancy rate of approximately 40%[16]. This percentage or less is coincidentally (33-39%) that at which the cumulative production of adults at an ANS would attain 25% cumulative mortality, when the colony's growth rate replicates that observed at Coquet Island. When using a logistic growth rate of 50% with productivity set at 0.6 fledglings per pair, the cumulative production of adults at an ANS would attain 93% cumulative mortality with 55% occupancy of the colony site.

8.1.1.4 Table 8.1 shows modelled outputs of the time taken to repay mortality debt[15] at differing rates of colony growth, productivity and initial colony size, when using the logistic growth rate model. There is no evidence to suggest that colony size will follow any of the trajectories presented here in reality; this is in part due to several external factors which the colony could be impacted by (both negatively and positively), such as severe weather events or changes in food availability. However, the model accommodates for a decreasing growth rate with time, which for the example in Figure 8.5, declines from 50% to 22% by the 21st breeding season of an ANS and to 1% by the 27th breeding season of an ANS, the direction and scale if not the timeline of percentage change, comparable to colonies monitored.

[14] 25% cumulative mortality from a predicted 73 collision per annum over the lifetime of the Hornsea Three (35 years) equates to 639 birds i.e. 73 collisions x 35 years = 2,555 collisions, 25% of which is 639 birds.
[15] Mortality debt is the cumulative mortality incurred at that time from predicted collisions at Hornsea Three that remains after deducting the cumulative adult production from chicks fledged at the ANS.
[16] A higher level of occupancy than 40% would be expected at each of the four ANS on account of having optimised the location and design of the structure for nesting kittiwake.

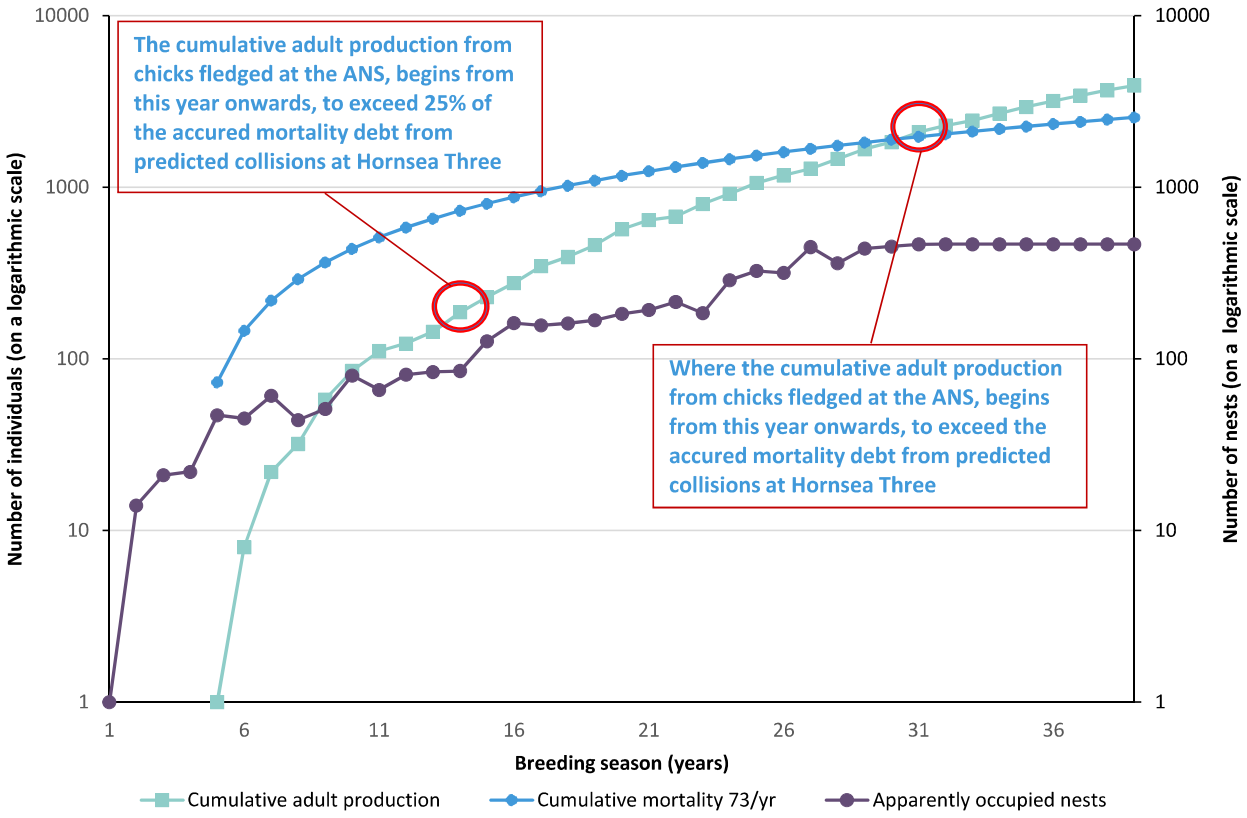


Figure 8.1 Graph of accumulated kittiwake mortality at a rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of the initial colony, growth rate and productivity being that as recorded at Coquet Island [17,18].

[17] The initial colony size, growth rate and its productivity assumes that recorded at Coquet Island from Year 1 (in 1991) to Year 29 (in 2019), with a logistic growth model and productivity of 1.07 (mean fledglings per pair, 2015-2019 at Coquet Island) used for the remaining years to best describe what may be predicted naturally for this colony.

[18] For Figures 6.1 – 6.8, when the cumulative production of adults crosses the cumulative mortality line, 100% of cumulative mortality for the lifetime of Hornsea Three has been compensated.

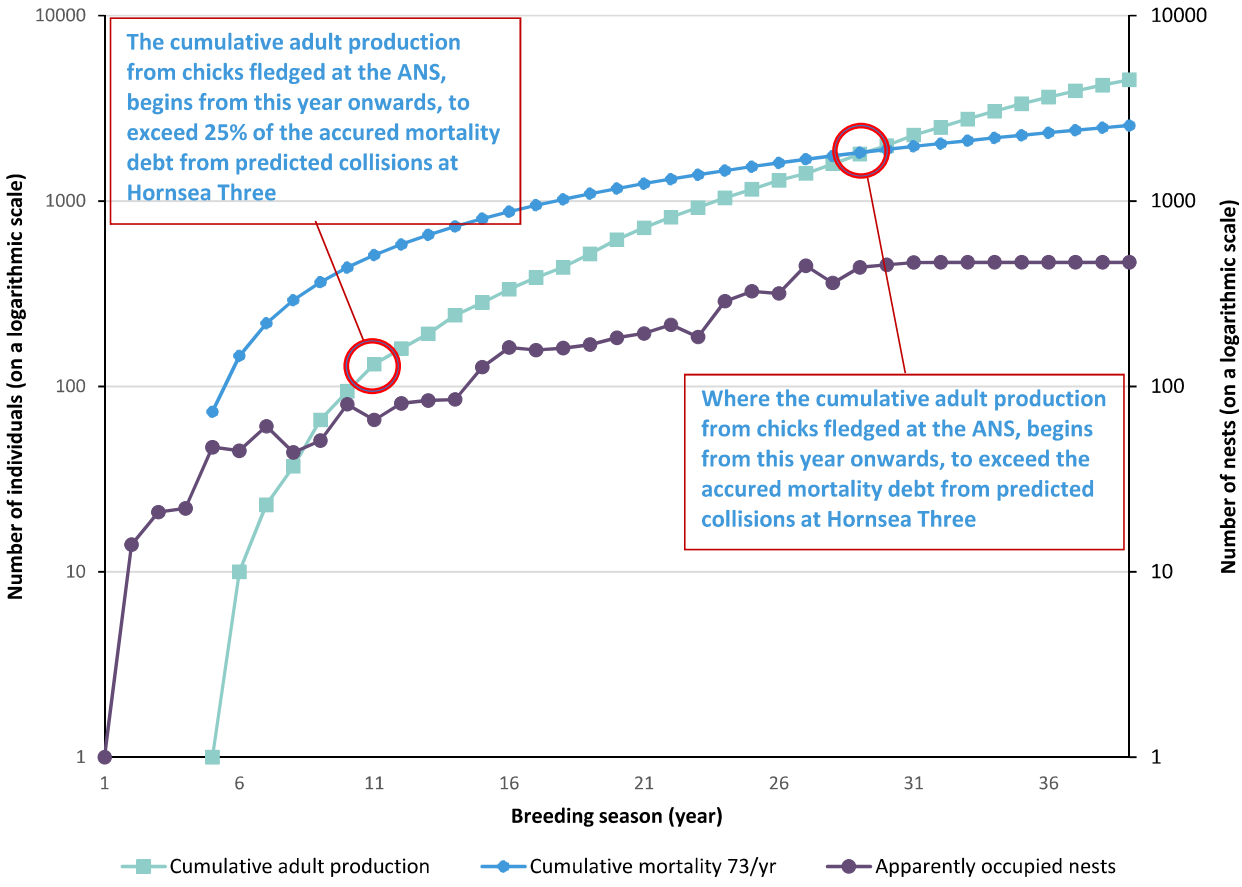


Figure 8.2 Graph of accumulated kittiwake mortality at rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of the initial colony and growth rate being that as recorded at Coquet Island, and productivity as that averaged in Lowestoft (1.27; 2021).

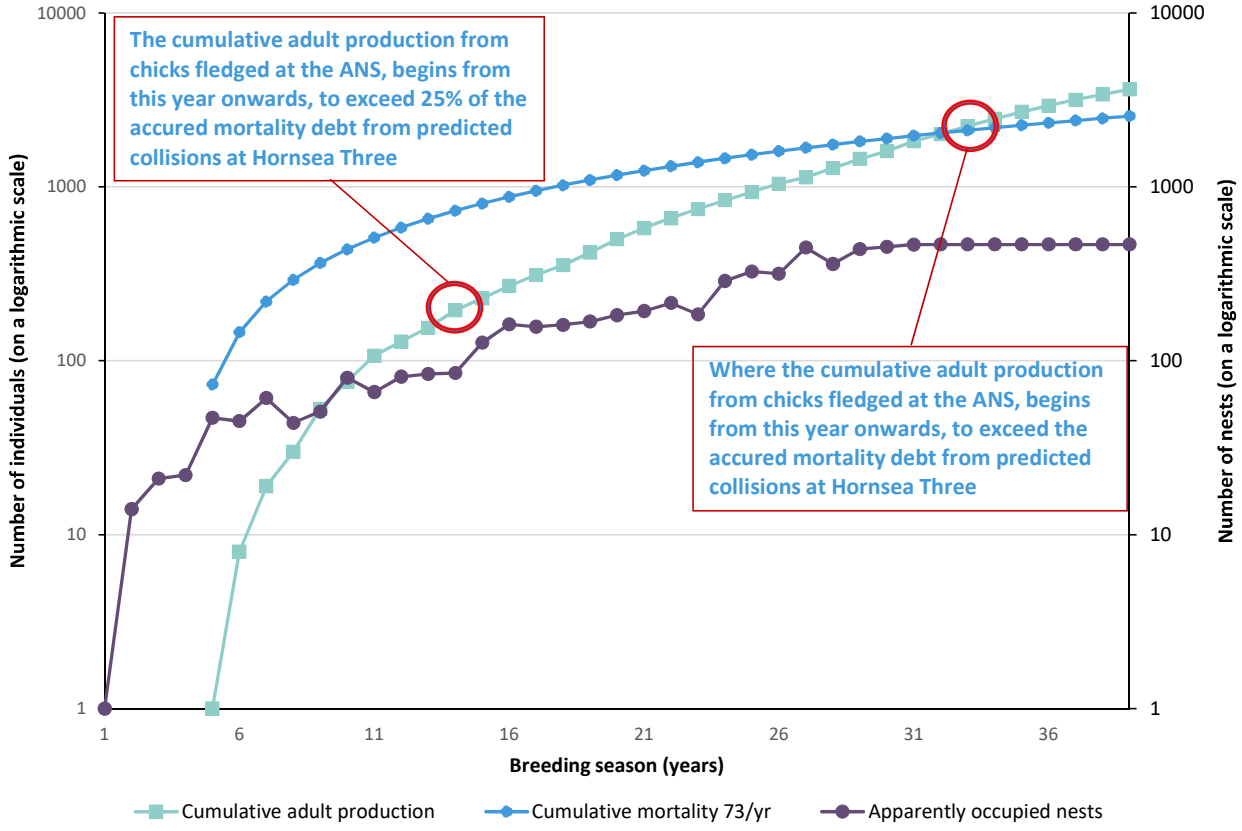


Figure 8.3 Graph of accumulated kittiwake mortality at rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of the initial colony and growth rate being that as recorded at Coquet Island, and productivity as that averaged in Lowestoft (1.025; 2013-2017).

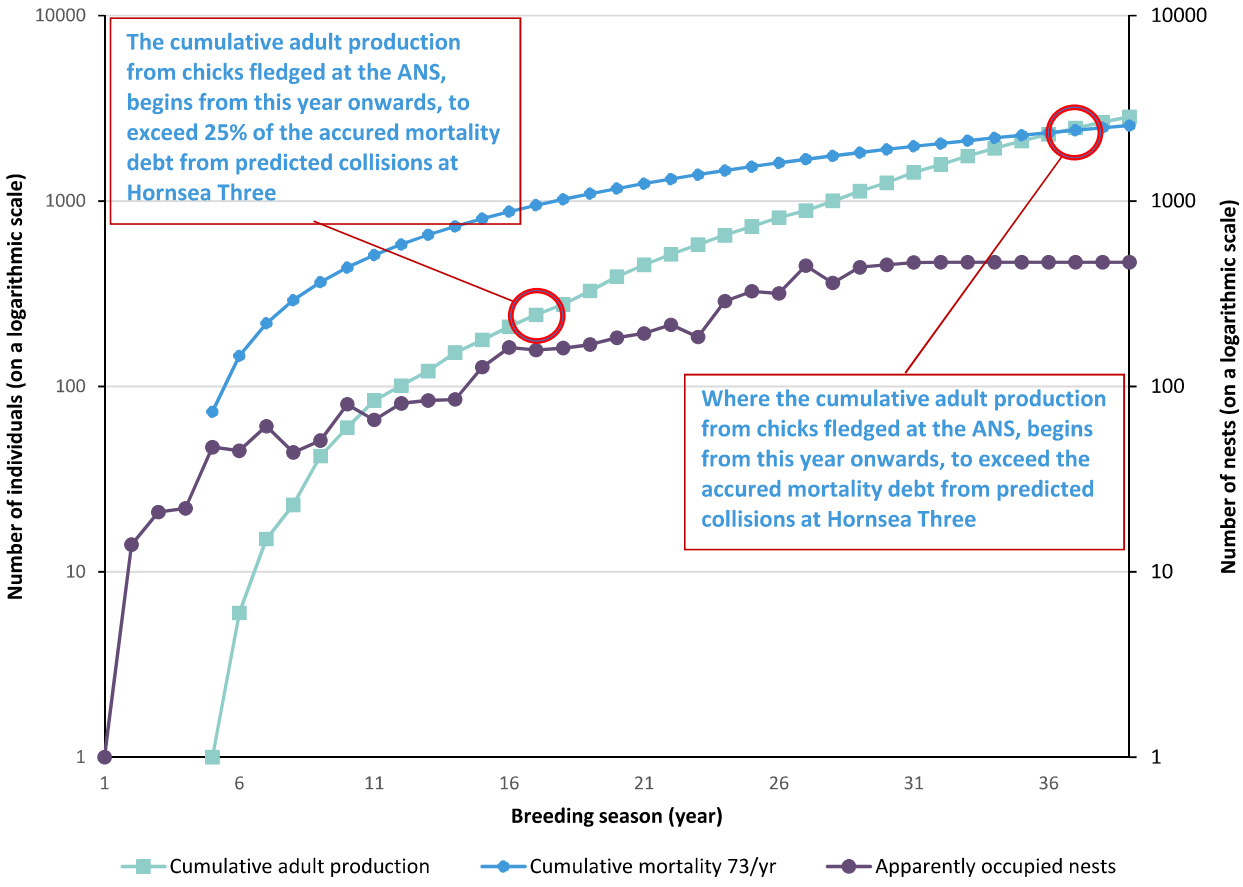


Figure 8.4 Graph of accumulated kittiwake mortality at rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of the initial colony and growth rate being that as recorded at Coquet Island, and productivity being 0.8 fledglings per pair.

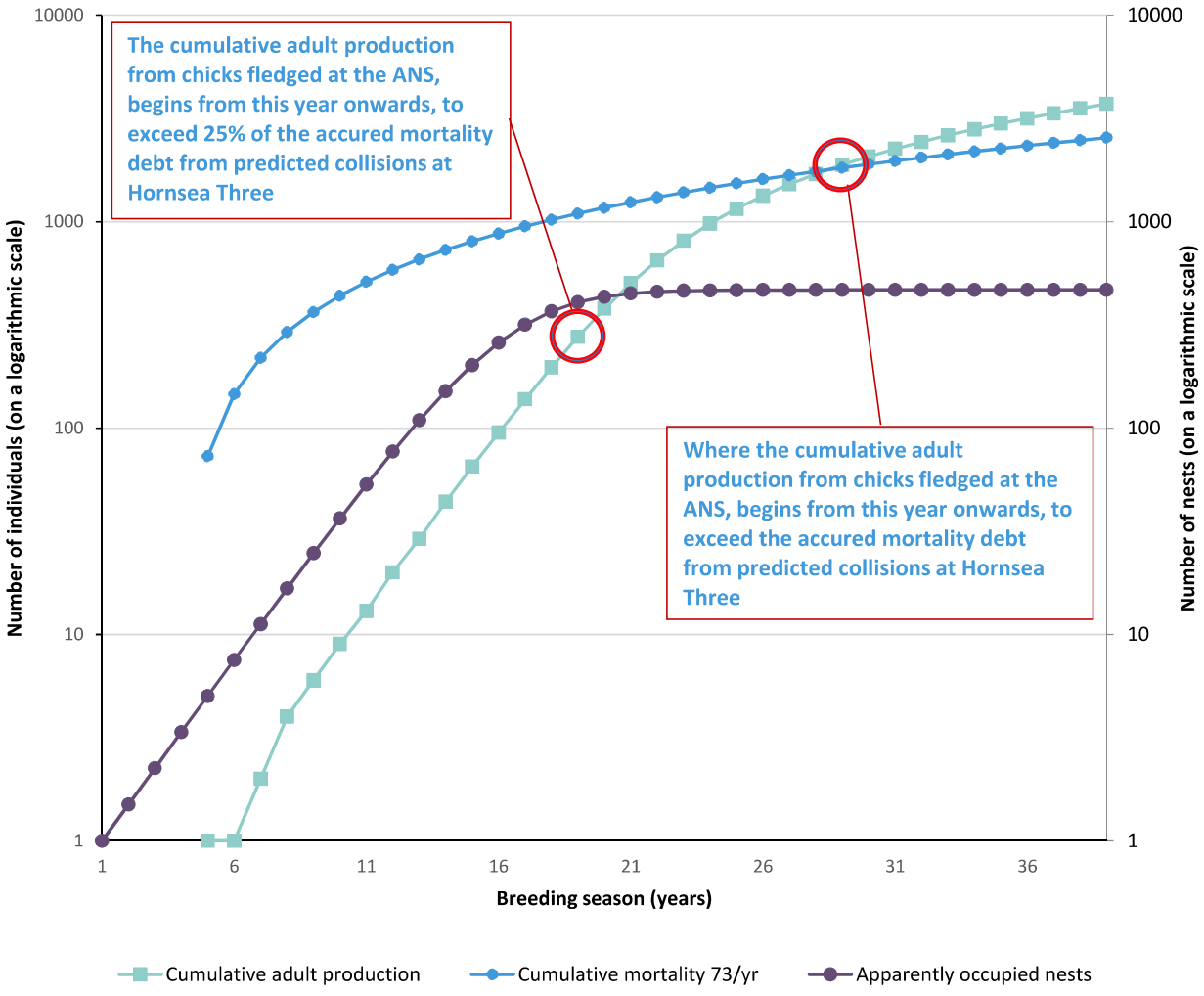


Figure 8.5 Graph of accumulated kittiwake mortality at rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of the initial colony of one nest, logistic growth rate of 50% and productivity being 0.8 fledglings per pair.

Table 8.1 Modelled accumulation of collision mortality at Hornsea Three against production of adults (assuming first breeding at 4 years old) and various colony logistic growth rates, productivity assumptions, based on an initial colony size of 1 pair. Shaded cell indicates year in which cumulative adult production from chicks fledged at the ANS, begins to exceed 25% (yellow) and 100% (green) accrued mortality debt from predicted collisions at Hornsea Three.

Breeding Season of an	Accumulated mortality at Hornsea		Cumulative total of the production of adults (colony initiation in Year 1)								
		Initial colony growth rate	20%	20%	20%	50%	50%	50%	80%	80%	80%
		Initial colony size (AON)	1	1	1	1	1	1	1	1	1
		Productivity (fledglings/ nest)	0.8	1.025	1.27	0.8	1.025	1.27	0.8	1.025	1.27
1	0		0	0	0	0	0	0	0	0	0
2	0		0	0	0	0	0	0	0	0	0
3	0		0	0	0	0	0	0	0	0	0
4	0		0	0	0	0	0	0	0	0	0
5	73		1	1	1	1	1	1	1	1	1
6	146		1	2	2	1	2	2	2	2	2
7	219		2	2	3	2	3	3	3	4	4
8	292		3	3	4	4	5	6	5	6	8
9	365		3	4	5	6	7	9	9	12	14
10	438		4	6	7	9	11	13	17	21	26
11	511		6	7	9	13	17	20	29	38	46
12	584		7	9	11	20	25	31	52	66	82
13	657		9	11	13	29	37	46	90	115	143
14	730		11	14	17	44	56	69	153	195	242
15	803		13	17	20	65	83	102	248	318	393
16	876		16	20	25	95	122	150	380	487	603
17	949		19	25	31	138	177	219	542	694	860
18	1022		24	30	37	197	253	313	719	921	1142
19	1095		29	36	45	277	354	439	902	1155	1431
20	1168		34	44	54	379	485	601	1085	1390	1722
21	1241		42	53	66	503	645	799	1269	1626	2014
22	1314		50	64	79	648	830	1029	1453	1861	2306
23	1387		60	77	95	808	1035	1283	1637	2097	2598
24	1460		72	92	114	979	1254	1553	1820	2332	2890
25	1533		86	110	136	1155	1480	1834	2004	2568	3181
26	1606		103	132	163	1335	1711	2120	2188	2803	3473
27	1679		123	157	194	1517	1944	2409	2372	3039	3765
28	1752		146	187	231	1700	2178	2699	2556	3274	4057
29	1825		173	222	275	1884	2413	2990	2740	3510	4349
30	1898		205	263	326	2067	2648	3281	2923	3745	4641
31	1971		243	311	385	2251	2884	3573	3107	3981	4932
32	2044		286	366	454	2435	3119	3865	3291	4216	5224
33	2117		336	430	533	2618	3355	4157	3475	4452	5516
34	2190		393	504	624	2802	3590	4448	3659	4688	5808
35	2263		458	587	727	2986	3826	4740	3843	4923	6100
36	2336		532	681	844	3170	4061	5032	4026	5159	6392
37	2409		614	787	975	3354	4297	5324	4210	5394	6683
38	2482		706	904	1120	3538	4532	5616	4394	5630	6975
39	2555		806	1033	1280	3721	4768	5907	4578	5865	7267

8.2 Scenario Two – initial colony size of 25 AON

8.2.1.1 **Figure 8.6** to **8.10** show the cumulative production of kittiwake and accumulated kittiwake mortality from predicted collisions at Hornsea Three. Each model is based on initial colony size of 25 AONs on the ANS when the windfarm becomes operational, but otherwise uses identical parameter values to the models of Scenario One (as stated in **Section 8.1** above). However, the initial growth value is taken from that between the second and third breeding season of the colony i.e. 50%, when using growth rate of the kittiwake colony at Coquet Island, as opposed to the 1,300% increase noted the previous year when the colony expanded from an initial one nest to 14 nests. This precautionary approach is taken in the absence of any known examples of a colony at approximately 25 nests exhibiting a comparable or greater numerical increase the following year to 350 nests (i.e. 1,300%). As previously described (see **Section 4.2.1.2** in using a ceiling of 467 AON), a modelled 0.2% for, in this case, the period years 31 to 39, using a logistic growth rate for those nine years after the last real count data in 2021.

8.2.1.2 In common to Scenario One, **Figure 8.6** to **8.10** is for one ANS, there being four ANS proposed for the Hornsea Three kittiwake compensation measure. Therefore, progress should be viewed in delivering cumulatively across the structures and lifetime of the project which equates to 73 additional birds per annum over the lifetime of Hornsea Three (35 years). If colonisation, growth rate and productivity were equal across all four ANS, then the compensation measure would be delivered cumulatively across the structures when the cumulative production of adults at each ANS attains 25% cumulative mortality from predicted collisions at Hornsea Three (i.e. 639 additional breeding birds to the existing wider breeding population). This would be achieved between the 13th and 19th breeding season of an ANS depending on the four productivity scenarios when using an initial colony size of 25 nests. Moreover, the cumulative adult production from chicks fledged at the ANS, begins to exceed 25% of the accrued mortality debt from predicted collisions at Hornsea Three from between the 6th and 8th breeding season of an ANS depending on the four productivity scenarios above.

8.2.1.3 **Table 8.2** shows further examples to those already present in **Table 8.1**, of modelled outputs of the time taken to repay mortality debt at further differing rates of colony growth, productivity and initial colony size, when using the logistic growth rate model. As noted previously (see **Section 8.1.1.4**), this model accommodates for a decreasing growth rate with time and fluctuating productivity values, which for the example shown in **Figure 8.6**, declines from 50% to 22% by the 13th breeding season of an ANS and to 1% in 19th breeding season of an ANS.

8.2.1.4 **Table 8.3** presents some of the data from **Figure 8.7** to **Figure 8.10,** i.e. the modelled outputs of the time taken to repay mortality debt at differing rates of productivity, from an initial colony size of 25 and when using the growth rates observed at the Coquet Island colony over the last 30 years.

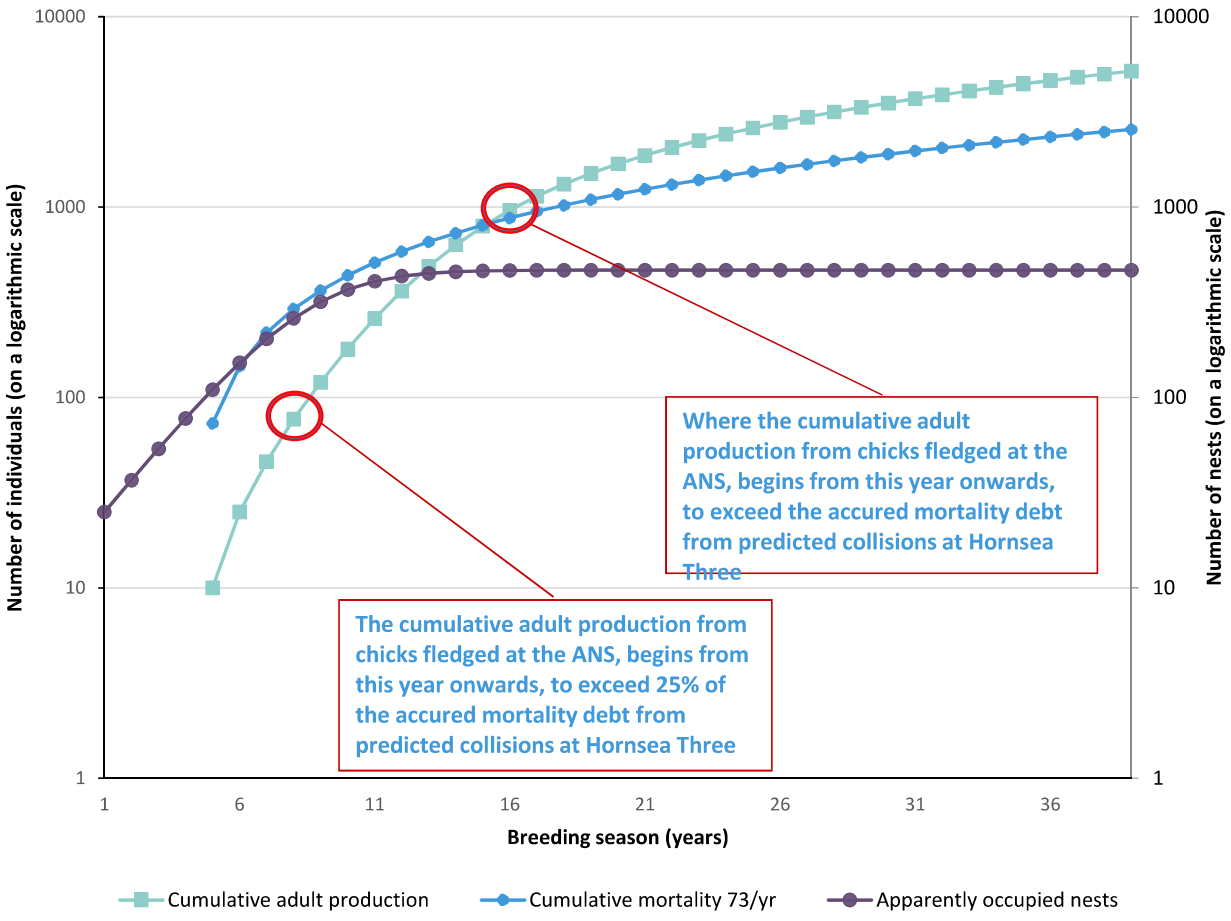


Figure 8.6 Graph of accumulated kittiwake mortality at rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of an initial colony of 25 nests, logistic growth rate of 50% and productivity being 0.8 fledglings per pair.

Table 8.2 Modelled accumulation of collision mortality at Hornsea Three against production of adults (assuming first breeding at 4 years old) and various colony logistic growth rates, productivity assumptions, based on an initial colony size of 25 pairs. Shaded cell indicates year in which cumulative adult production from chicks fledged at the ANS, begins to exceed 25% (yellow) and 100% (green) accrued mortality debt from predicted collisions at Hornsea Three.

Breeding Season of an ANS	Accumulated mortality at Hornsea Three (Operational from Year 5)		Cumulative total of the production of adults (colony initiation in Year 1)								
		Initial colony growth rate	20%	20%	20%	50%	50%	50%	80%	80%	80%
		Initial colony size (AON)	25	25	25	25	25	25	25	25	25
		Productivity (fledglings/ nest)	0.8	1.025	1.27	0.8	1.025	1.27	0.8	1.025	1.27
1	0		0	0	0	0	0	0	0	0	0
2	0		0	0	0	0	0	0	0	0	0
3	0		0	0	0	0	0	0	0	0	0
4	0		0	0	0	0	0	0	0	0	0
5	73		10	13	16	10	13	16	10	13	16
6	146		22	28	35	25	32	39	28	35	44
7	219		36	46	57	46	59	73	57	73	91
8	292		52	67	83	77	98	121	107	137	170
9	365		72	92	114	120	153	190	186	238	295
10	438		95	121	150	180	230	285	301	386	478
11	511		122	156	193	260	333	412	450	577	715
12	584		153	196	243	362	464	575	622	797	987
13	657		190	243	302	488	624	774	803	1029	1274
14	730		233	298	369	633	811	1004	986	1263	1565
15	803		282	361	447	793	1016	1259	1170	1499	1857
16	876		338	433	537	964	1235	1530	1354	1734	2149
17	949		403	516	639	1141	1461	1810	1537	1970	2440
18	1022		475	609	754	1321	1692	2096	1721	2205	2732
19	1095		557	713	884	1503	1925	2385	1905	2441	3024
20	1168		647	829	1027	1686	2160	2676	2089	2676	3316
21	1241		747	957	1185	1869	2394	2967	2273	2912	3608
22	1314		856	1096	1358	2053	2630	3258	2457	3147	3899
23	1387		973	1247	1545	2236	2865	3550	2640	3383	4191
24	1460		1099	1409	1745	2420	3101	3842	2824	3618	4483
25	1533		1234	1580	1958	2604	3336	4133	3008	3854	4775
26	1606		1375	1761	2182	2788	3572	4425	3192	4089	5067
27	1679		1523	1951	2417	2971	3807	4717	3376	4325	5359
28	1752		1676	2148	2661	3155	4043	5009	3560	4560	5650
29	1825		1835	2351	2913	3339	4278	5301	3743	4796	5942
30	1898		1998	2560	3172	3523	4514	5592	3927	5032	6234
31	1971		2165	2773	3436	3707	4749	5884	4111	5267	6526
32	2044		2335	2991	3706	3891	4985	6176	4295	5503	6818
33	2117		2507	3212	3980	4074	5220	6468	4479	5738	7110
34	2190		2682	3436	4257	4258	5456	6760	4662	5974	7401
35	2263		2858	3661	4537	4442	5691	7051	4846	6209	7693
36	2336		3036	3889	4819	4626	5927	7343	5030	6445	7985
37	2409		3215	4118	5103	4810	6162	7635	5214	6680	8277
38	2482		3394	4349	5388	4994	6398	7927	5398	6916	8569
39	2555		3575	4580	5675	5177	6633	8219	5582	7151	8860

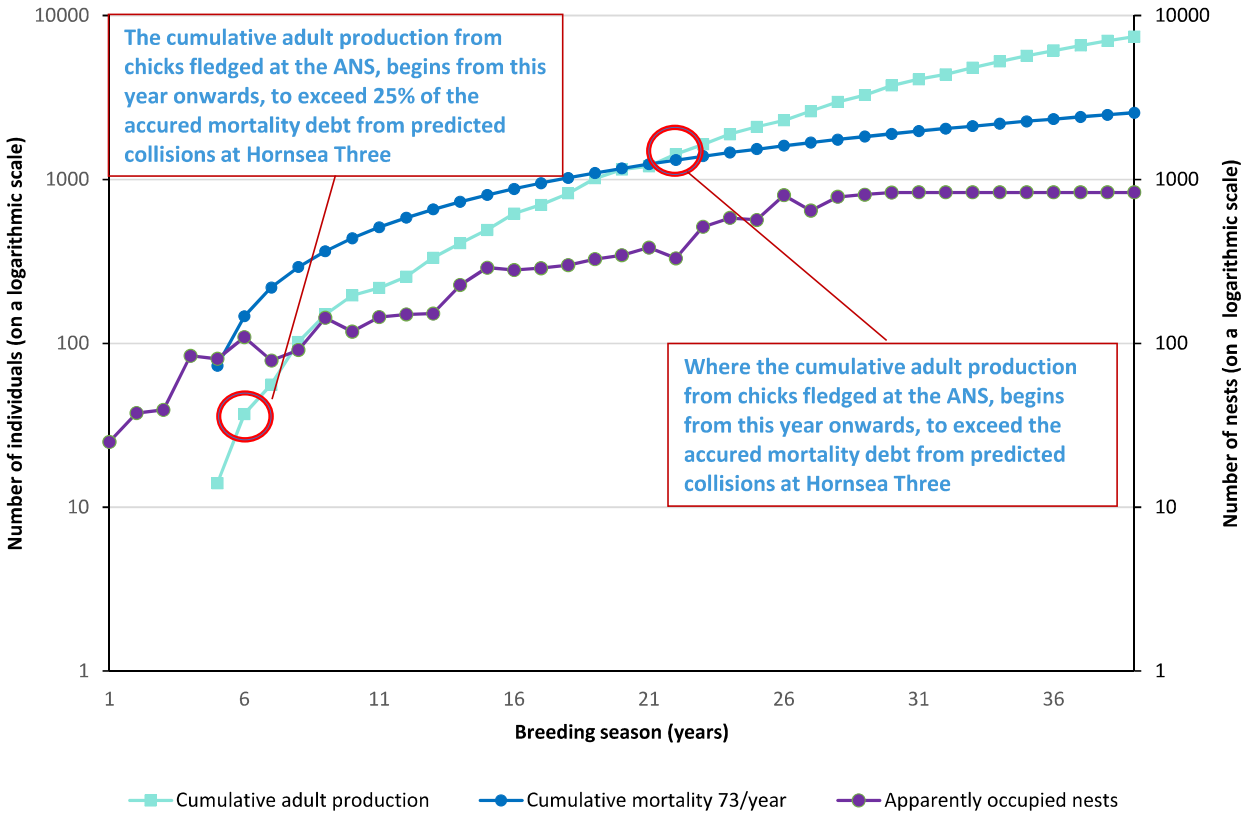


Figure 8.7 Graph of accumulated kittiwake mortality at a rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of an initial colony of 25 nests, with a growth rate and productivity matching that recorded at Coquet Island[19].

[19] The initial colony size, growth rate and its productivity assumes that recorded at Coquet Island from Year 1 (in 1991) to Year 29 (in 2019), with a logistic growth model and productivity of 1.07 (mean fledglings per pair, 2015-2019 at Coquet Island) used for the remaining years to best describe what may be predicted naturally for this colony.

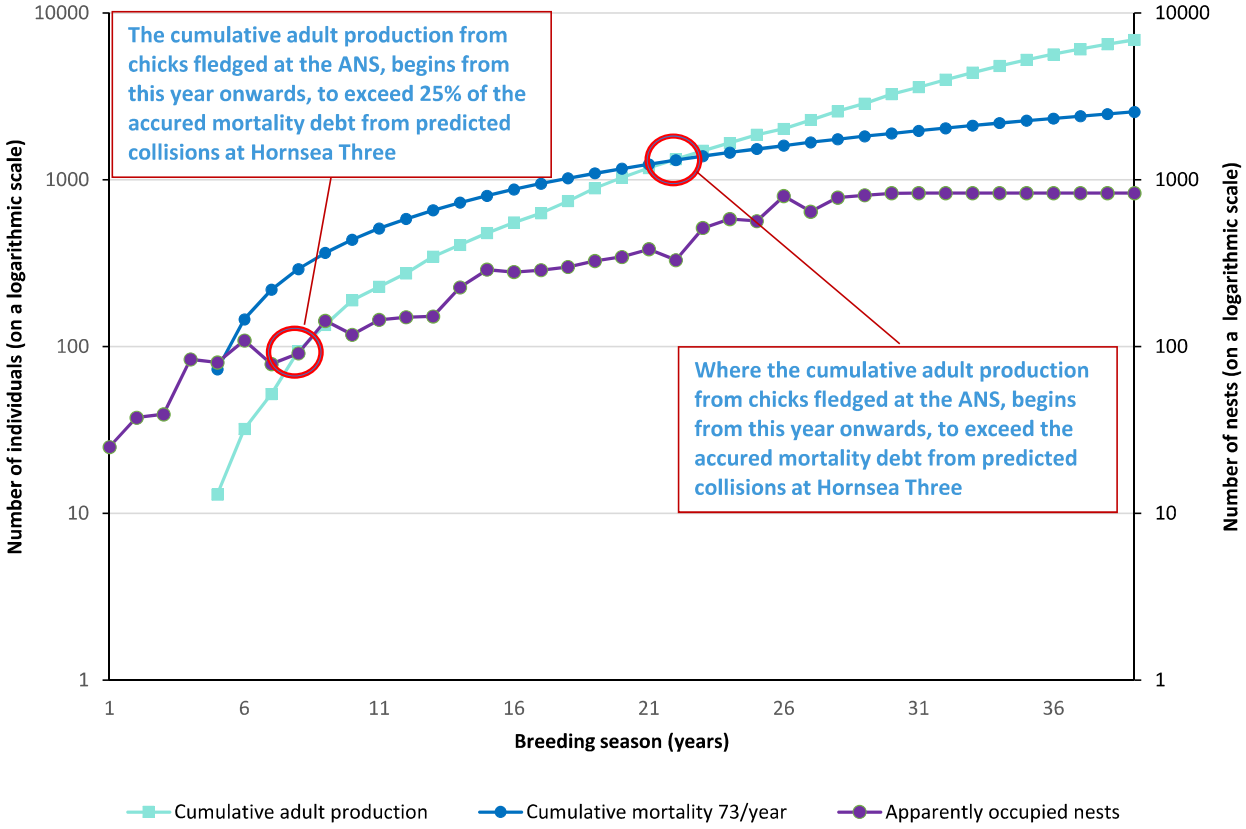


Figure 8.8 Graph of accumulated kittiwake mortality at rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of an initial colony of 25 nests a growth rate matching that recorded at Coquet Island, and productivity as that averaged in Lowestoft (1.025; 2013-2017).

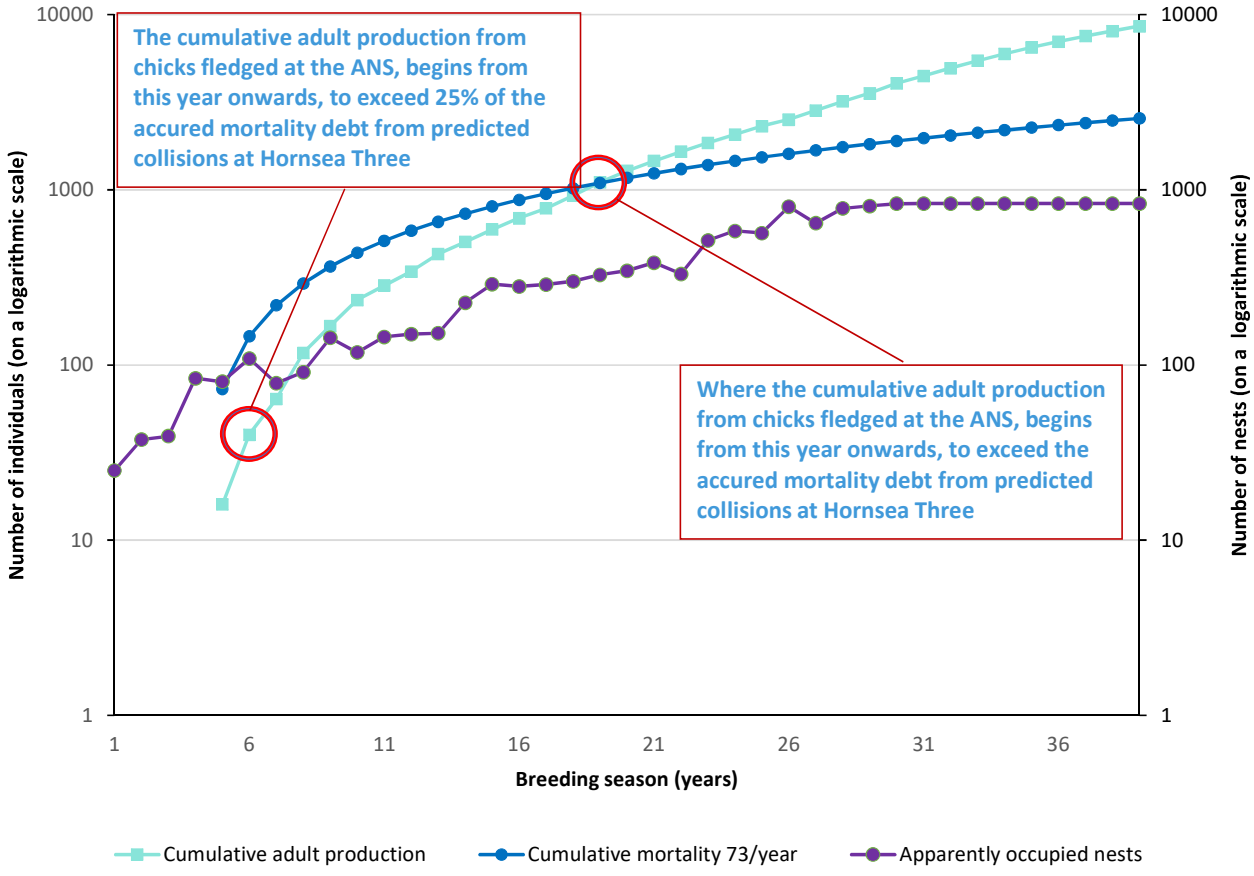


Figure 8.9 Graph of accumulated kittiwake mortality at rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of an initial colony of 25 nests, a growth rate that matches that recorded at Coquet Island, and productivity as that in Lowestoft (1.27; 2021).

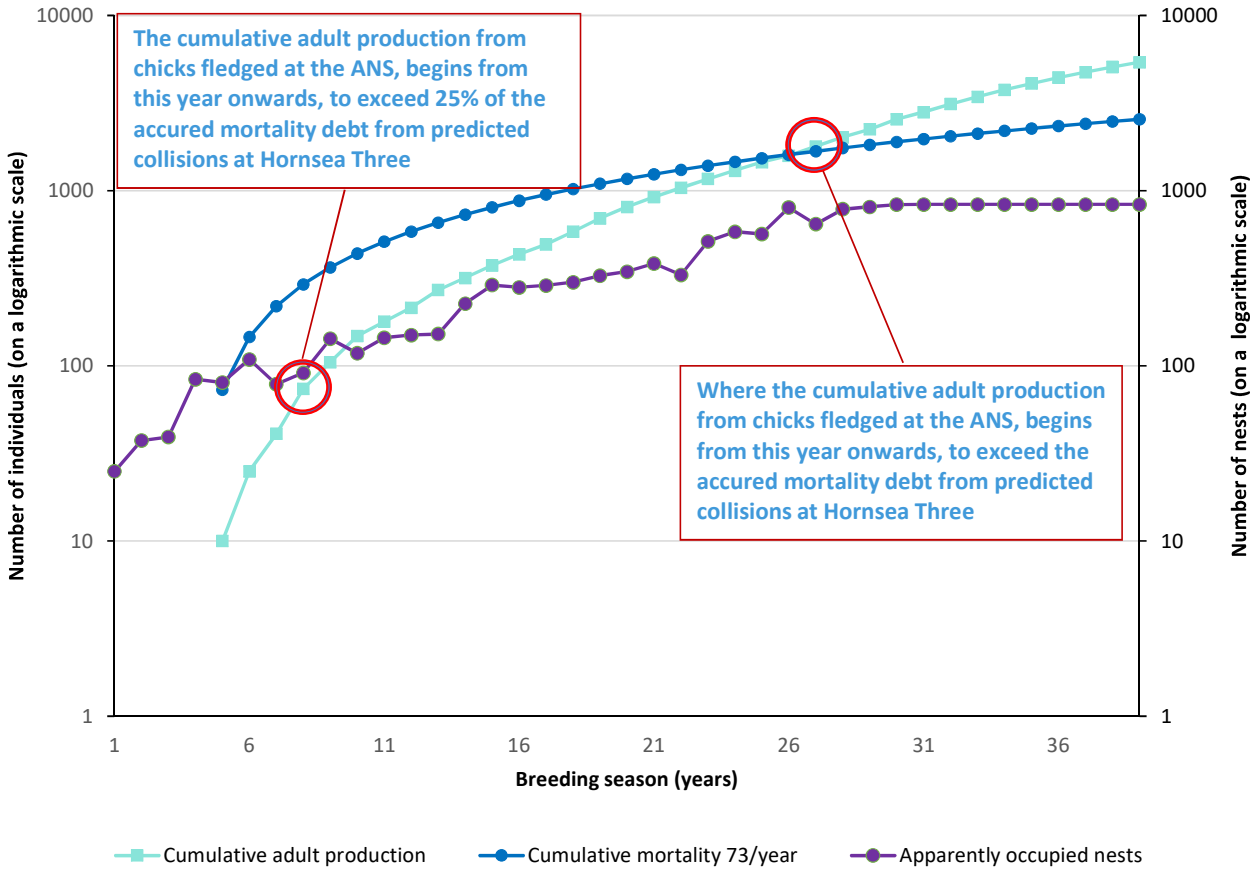


Figure 8.10 Graph of accumulated kittiwake mortality at rate of 73 birds per annum and the size of a new colony with its cumulative production of adults, under the assumptions of the initial colony of 25 nests and growth rate being that as recorded at Coquet Island, and productivity of 0.8 fledglings per pair.

Table 8.3 Modelled accumulation of collision mortality at Hornsea Three against production of adults (assuming first breeding at 4 years old) and growth rates based on those observed at Coquet Island, across various productivity assumptions, based on an initial colony size of 25 pairs. Shaded cell indicates year in which cumulative adult production from chicks fledged at the ANS, begins to exceed 25% (yellow) and 100% (green) accrued mortality debt from predicted collisions at Hornsea Three.

Breeding Season of an ANS	Accumulated mortality at Hornsea		Cumulative total of the production of adults (colony initiation in Year 1)			
		Colony growth rate	Coquet Island, 1991-2021			
		Initial colony size (AON)	25	25	25	25
		Productivity (fledglings/ nest)	0.8 (Coulson 2017)	1.025 (5 year mean (2013-2017), Lowestoft)	1.27 (2021, Lowestoft)	0.4 – 1.69 (matching Coquet Island, 1993-2019)
1	0		0	0	0	0
2	0		0	0	0	0
3	0		0	0	0	0
4	0		0	0	0	0
5	73		10	13	16	14
6	146		25	32	40	37
7	219		41	52	64	56
8	292		74	94	117	102
9	365		105	135	167	150
10	438		148	190	235	196
11	511		179	229	284	218
12	584		215	275	341	255
13	657		271	347	430	333
14	730		318	407	504	408
15	803		374	480	594	493
16	876		433	555	688	618
17	949		493	632	783	701
18	1022		583	746	924	821
19	1095		696	892	1105	1016
20	1168		807	1034	1280	1150
21	1241		920	1179	1460	1206
22	1314		1038	1330	1648	1428
23	1387		1167	1495	1852	1637
24	1460		1302	1669	2067	1891
25	1533		1453	1862	2307	2097
26	1606		1583	2029	2513	2293
27	1679		1786	2289	2835	2613
28	1752		2015	2582	3199	2976
29	1825		2238	2868	3552	3273
30	1898		2553	3271	4052	3745
31	1971		2807	3596	4455	4084
32	2044		3115	3992	4945	4379
33	2117		3433	4400	5450	4806
34	2190		3761	4819	5970	5246
35	2263		4089	5240	6491	5686
36	2336		4417	5661	7012	6126
37	2409		4746	6081	7533	6567
38	2482		5074	6502	8054	7007
39	2555		5402	6923	8575	7448

9 Impact of delayed colonisation

9.1.1.1 In each of the scenarios presented in **Figure 8.1** – **8.5** when the initial size of colony is one nest, the cumulative adult production from chicks fledged at the ANS, begins to exceed 25% of the accrued mortality debt from predicted collisions at Hornsea Three from between the 11th and 20th breeding season of an ANS depending on the five productivity scenarios above. This time window between colony initiation and when the ANS recruitment into the breeding adult population begins to exceed 25% of the accrued mortality debt from predicted collisions at Hornsea Three, is reduced to between the 6th and 8th breeding season when the initial size of colony is 25 nests. All models of either scenarios of initial size of colony as presented in **Figure 8.1** - **8.10**, achieve exceeding 25% of the accrued mortality debt comfortably within the expected 35 year lifespan of Hornsea Three.

9.1.1.2 The four ANS proposed for the Hornsea Three kittiwake compensation measure will include two offshore structures off the Suffolk coast. It is therefore pertinent to note when reflecting on the above summarised results, that the modelled scenarios of colony growth have been parametrised by rates of growth and productivity recorded at onshore colonies, where breeding success has been shown to be lower than colonies on offshore structures within the same part of coast (Christensen-Dalsgaard *et al.* 2019). This is evidenced in Suffolk where these two offshore ANS are proposed, by productivity of the colonies on the two nearshore rigs at Sizewell recorded as 1.38 and 1.15 fledgings per nest in 2021 and 2022 respectively, whereas it was 1.27 and 0.99 at nearby Lowestoft town (NIRAS 2021, 2022).

9.1.1.3 The above findings suggest that any delay in colonisation would result in an equivalent delay for compensation to exceed mortality (i.e. pay back of the mortality debt). This is irrespective of which scenario of growth rate, productivity or initial colony size occurs. Every year of delay in initial colonisation of an ANS is another year before the ANS achieves compensation for either a quarter or all of the collision mortality debt. This holds true irrespective of the scenario considered for colony growth rate, productivity and number of nests at initial colonisation of those plotted in **Figure 8.1** - **8.10.**

9.2 Potential impact of a delay on SPA populations and network coherence

9.2.1.1 There is, for all breeding populations, a range of parameter value combinations below for which a colony is not self-sustaining and before which excess productivity falls below a specified level (e.g. dispersal of 73 breeding adults into the wider population). What is of ecological pertinence to Hornsea Three is that cumulatively across the four ANS, the agreed annual excess productivity is attained and maintained, with the accrued debt fully compensated, at a point within the windfarm's operational lifespan. A realistic timeframe for this, when reviewing a range of predicted scenarios as in the preceding tables (**Table 8.1**, **Table 8.2**, and **Table 8.3**), is that captured by those scenarios whose parameter values lie within recent and known natural variation. That excess productivity of an ANS does not rise above a specified level (e.g. dispersal of 73 breeding adults into the wider population) within the infancy of the windfarm's operational lifespan, does not reflect failure. To identify where the cut-off lies when productivity is falling below a specified level, evitability scenarios need to be run that fail to achieve the set objective. Of the 26 scenarios presented, it is where a combination of the parameter values lie outside the range of recent natural variability (i.e. initial colony growth rate of 20%; see **section 4.1**), that the ANS is predicted to fail to accumulated adult production that exceeds more than 25% of the accumulated mortality from collision predicted over 35 years.

9.2.1.2 For those scenarios where the controlling parameter values lie within the range of recent natural variability, they suggest any delay of up to a few years in their colonisation by kittiwake will have no consequence on the effectiveness of the proposed compensation measure with respect to the Flamborough and Filey Coast Special Protection Area (FFC SPA) population (or wider North Sea population) or coherence of the network for kittiwake. Such a delay in the agreed annual excess productivity being attained and maintained, with the accrued debt fully compensated, is proportionately small temporally and numerically in the wider context, that it will not represent any meaningful and detectable impact in the coherence of the network for kittiwake. The planned compensation measures will be in place over the long-term (35+ years) so a delay of one to a few years would have a *de minimis* impact on the overall success of these measures.

10 References

Coulson, J.C. (2011). *The Kittiwake*. T. & A.D. Poyser, London.

Coulson, J.C. (2017). Productivity of the black-legged kittiwake *Rissa tridactyla* required to maintain numbers. *Bird Study* 64: 84-89.

Christensen-Dalsgaard, S., Langset, M. and Anker-Nilssen, T. (2019). Offshore oil rigs – a breeding refuge for Norwegian black-legged kittiwakes *Rissa tridactyla*? *Seabird* 32: 20-32.

Horswill, C. and Robinson, R.A. (2015). *Review of seabird demographic rates and density dependence*. JNCC Report No. 552. JNCC, Peterborough.

Kildaw, S.D., Irons, D.B., Nysewander, D.R. & Buck, C.L. (2005). Formation and growth of new seabird colonies: the significance of habitat quality. *Marine Ornithology* 33: 49-58.

Natural England (2021). *Norfolk Boreas Offshore Wind Farm: Natural England's advice on the Flamborough and Filey Coast Special Protection Area (FFC SPA) in principle compensation measures*. Planning Inspectorate Reference: EN010087

Orsted (2020). *Response to the Secretary of State's Minded to Approve Letter Annex 2 to Appendix 2 (Kittiwake Compensation Plan): Kittiwake Artificial Nest Provisioning: Ecological Evidence*. Orsted Hornsea Project Three (UK) Ltd., London.

NIRAS (2021). *Annual Monitoring Report of Onshore Kittiwake Colonies 2021*. Report commissioned by Orsted Hornsea Project Three (UK) Ltd.. NIRAS (UK) Group Ltd., Cambridge, UK.

NIRAS (2022). *Annual Monitoring Report of Onshore Kittiwake Colonies 2022*. Report commissioned by Orsted Hornsea Project Three (UK) Ltd.. NIRAS (UK) Group Ltd., Cambridge, UK.

Vandermeer, J. (2010) How Populations Grow: The Exponential and Logistic Equations. *Nature Education Knowledge* 3(10):15 https://www.nature.com/scitable/knowledge/library/how-populations-grow-the-exponential-and-logistic-13240157/ (Accessed 20th November 2022).